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ON THE COMPANIONS OF THE PERIODIC COMET 1889 V,

By S. C. Chandler.

Only one of the components of this comet has apparently been seen at this return. It has been generally assumed that this is identical with the fragment *A* seen in 1889. It appears to me, however, that such identity has yet to be demonstrated; that it is indeed quite problematical, in view of the great alternations in the size and brightness of the four components seen in 1889. In support of this view I need only recall the fact that during the latter part of August and the early part of September of that year, the fragment *C* was actually brighter than *A*. Indeed, at one time even *B*, according to Barnard, had a brighter nucleus than *C*, and a smaller and less diffused coma. There is danger then that, unless another component is discerned at this appearance, the theory of the comet will be left in an imperfect condition, — resting as it does on the unstable hypothesis referred to. The case is analogous to that of Biela's comet, where the classical discussion by Hubbard left the identity of the components seen in 1846 and 1852 an unsettled question.

The matter deserves the serious attention of astronomers. I accordingly give an ephemeris of the component *C* for October, from which it will be seen that its general situation with reference to *A* is about $12^{s}.5$ following, and $1'.4$ north. In my discussion of the relative orbits, *A.J.*, X, 153, 161, I found that the planes and eccentricities of the orbits of *A* and *C* were the same, and that the differences of the other elements could be expressed, in the sense $A-C$, by

$$\begin{aligned} \Delta T &= -0^{d}.2321 \\ \Delta\omega &= -186''.28 \\ \Delta q &= -0.000456 \end{aligned}$$

Applying these differences to Bauschinger's elements of *A*, with the perturbations as brought up to 1896 by Poor, and corrected by the current observations of the present comet, on the assumption of its identity with *A*, we have the elements of *C*,

$$\begin{aligned} T &= 1896 \text{ Nov. } 3.9297 \text{ Greenw. M.T.} \\ \omega &= 343^{\circ}\ 44'\ 39''.6 \\ \Omega &= 18\ \ \ 1\ \ \ 7.8 \\ i &= 6\ \ \ 3\ \ 34.1 \\ \log a &= 0.567264 \\ \mu &= 500''.161 \end{aligned}$$

whence the following ephemeris for *C*,

1896 Gr. M.T.	App. α	App. δ	log Δ
	h m s	° ′	
Oct. 3.5	22 8 15	−17 8.3	0.05228
7.5	8 48	16 40.0	.06154
11.5	9 53	16 9.1	.07139
15.5	11 29	15 35.9	.08174
19.5	13 36	15 0.3	.09252
23.5	16 10	14 22.7	.10363
27.5	19 14	13 43.2	.11499
31.5	22 22 43	−12 59.6	0.12650

REDISCOVERY AND MEASUREMENT OF THE COMPANION OF *SIRIUS*,

MADE WITH THE 24-INCH REFRACTOR OF THE LOWELL OBSERVATORY,

By T. J. J. See.

Twenty minutes before sunrise on the morning of August 31, Mr. Douglass kindly interrupted his regular work on *Mars*, in order to enable us to make a search for the companion of *Sirius*. The air was perfectly steady and clear from recent rains, and the seeing magnificent. On pointing the great telescope on *Sirius* I found nevertheless that the image was surrounded by considerable light, and for five minutes a search in the open field proved unavailing. A diaphragm was then inserted to screen off the light of the great star, and to enable us to examine the field more thoroughly for the faint satellite. Within a few minutes I perceived a faint star of the 11th magnitude in the third quadrant of position-angle; I noted the distance of the object as "between 4 and 5 seconds." On calling Mr. Douglass and Mr. Cogshall to the telescope they recognized the star, and I proceeded at once to measure the object. The seeing seemed to improve with the approach of sunrise, and the object became easier, and for about three minutes could be seen almost continuously as a yellow dot distinctly protruding from the rays of the large star. During this short interval I was able to look directly upon the object in the open field, and accordingly hastened the setting of the micrometer-threads. The first two readings gave an angle of 219°.5, and a distance of 5″.05. Mr. Douglass made the angle 225°.0, and Mr. Cogshall's estimate agreed substantially with these values. The rising of the sun came rapidly on; and with the increased illumination of the field some tremors of the atmosphere rendered the object more difficult. The seeing was still good, however, and I could see the object by occasional glimpses until some minutes after sunrise, though with less and less distinctness. The last setting indicated a somewhat greater distance (5″.88), but I think it is entitled to less confidence than the first measures.

The object has since been measured on several mornings, although the seeing has not been so satisfactory as on the morning of discovery. On Sept. 5 the object was seen with sufficient distinctness to enable me to recognize its yellow color, and to secure very satisfactory measures. It has been seen by all the members of the Observatory, including Mr. Lowell and Mr. Drew, who were absent when the discovery was made. The following are the results of our attempts to measure this most difficult object. The seeing is estimated on the scale of 10, which denotes absolute steadiness and the most perfect images possible.

Observations of the Companion of *Sirius*.

t	θ_o	ρ_o	Seeing	Remarks
	°	″		
1896.666	219.5	5.95	9	Comp. distinctly yellow, 4″.5 ±
1896.668	220.9	5.65	5	Est. $\rho = 6''$ ±
1896.671	220.2	5.28	5	Est. $\rho = 5''.8$ ±
1896.673	222.4	5.06	7	Bluish white, yellow, 5″.5 ±
1896.678	223.6	5.13	7	Good measures, $\rho = 5''.4$ ±
1896.692	218.8	4.74	5	Seen by glimpses only
1896.695	218.7	4.58	5	Seen with difficulty.
1896.678	220.6	5.07		

By Mr. Douglass

t	θ_o	ρ_o
	°	″
1896.666	225.0	—
1896.671	225.5	4.29
1896.678	225.0	6.28
1896.672	225.2	5.28

By Mr. Cogshall

t	θ_o	ρ_o
	°	″
1896.668	223.0	—
1896.671	228.0	6.65
1896.673	223.8	6.0 ±
1896.671	224.9	6.32

On account of the extreme difficulty of this object it will be apparent that the most harmonious results are not to be expected. While, therefore, the differences between the results obtained by the several observers are considerable, it does not seem probable that our mean value will be greatly in error.

The measure of the angle is undoubtedly more reliable than the distance, because the troublesome play of the fringes of the large star bewilder the observer in attempting to estimate the distance of the obscure companion, which is not sufficiently bright to be seen under the thread of the micrometer. Assuming the present position to be approximately $\theta = 220°$; $\rho = 5''.10$, it is clear that the theoretical predictions in regard to the motion of this body have not been fully verified. It has fallen about thirty degrees behind its predicted place, and receded correspondingly further from the central star. This will necessitate a revision of the elements, which will have an increased period of about 54 years, and a diminished eccentricity of approximately 0.5. It will probably not be possible to obtain *very exact measures*, such as are desirable in a final revision of the orbit, for about another year, but by that time it ought to be possible to define the position with the required precision. After the removal of the Observatory to the City of Mexico, in the course of a couple of months, I hope to secure additional measures, when *Sirius* is on the meridian and much nearer the zenith. Meanwhile the foregoing results are believed to be near the truth.

Lowell Observatory, Flagstaff, Arizona, 1896 *Sept.* 12.

NOTE ON THE BINARY STAR, LAC. 7215,

BY R. T. A. INNES, F.R.A.S.

This star, of which Prof. See gives an orbit in your Journal no. 372, is the chief star of *h* 4935, a wide pair observed by Sir John Herschel in 1837.5 whilst at the Cape. It is unlikely that the closer pair was then at its greatest distance = 1″.9. If it were allowable to suppose that Herschel observed it whilst at its least distance, the period would be about 27 years or about midway between the periods given by Burnham and See, viz.: 21.7 years and 33.0 years. But this again would make a period of close approach fall about 1865, which does not agree with the observation of this pair made at Melbourne in 1867, and published in the volume of *Astronomical Results* in 1869. It was there noted that the star was double, 7^{M} and 8^{M}, companion preceding. As the telescope used was the 5-in. meridian-circle and the companion was preceding, it must then have been an easy object; Prof. See's orbit agrees well with this. The star was next observed as a double by Mr. Burnham = to his β 416 on 1876 July 12, and again by Mr. Russell at Sydney on 1877 Aug. 24 = Russell 298, it being thought to be a new pair on these occasions.

Cape Observatory, 1896 *May* 27.

OBSERVATIONS OF SOUTHERN VARIABLES.

By ROBERT H. WEST.

62. *S Sculptoris.*

This star was under observation from 1895 November 8 to 1896 January 28. The 14 observations during this time yield a well-marked maximum on 1895 November 17, magnitude 6.5, notwithstanding the small number of observations before the maximum.

146. *T Sculptoris.*

Eighteen observations, from 1895 November 8 to 1896 February 4, give a maximum, with magnitude 7.85, for 1896 January 10. From December 7 to December 27 there was a noteworthy constancy in the star's light, magnitude 8.4.

1386. *T Eridani.*

The observations of this star number 15, from 1895 November 8 to 1896 March 18. A well-defined maximum, magnitude 7.35, is indicated for 1896 January 21.

1662. *R Caeli.*

This star was observed 11 times, from 1895 December 21 to 1896 March 18, during which time its brightness increased from $11^{M}.1$ to $7^{M}.8$, with no indication that it had reached its maximum.

2776. *W Puppis.*

Fourteen observations, from 1896 January 3 to April 29, give a maximum of $7^{M}.55$ on March 6. The observations also indicate a minimum of $9^{M}.8$ on January 18, but they are insufficient to warrant any definite conclusion. When last seen, the star was $10^{M}.2$. These observations fully confirm, of course, the variability announced by the Harvard College Observatory, and hitherto unconfirmed, so far as I am aware.

3425. *X Hydrae.*

Cloudy weather interfered with observation at the time of maximum, and hence the graphical determination of the maximum for 1896 April 8, magnitude 8.45, is somewhat uncertain. It is based on 15 observations, from 1895 December 27 to 1896 May 29.

C.DM. −24°7693.[*]

The variability of this star was suspected during the preparation of the Cordoba *Durchmusterung*, and it has been fully confirmed by an examination of the H.C.O. photographs (*A.N.*, 3362). Twelve observations, between 1896 February 2 and May 29, give independent confirmation, and in addition indicate a maximum of about $8^{M}.3$ on or before March 1. There are not sufficient observations before and at the time of the maximum to permit of a more definite determination.

4225. *X Centauri.*

Eight observations, from 1896 March 18 to June 12, fully confirm the variability of this star, announced by H.C.O. The brightness increased from $8^{M}.0$ to $7^{M}.7$, and then decreased, at first slowly, but afterwards more rapidly, to $9^{M}.6$ at the last observation. The variation from March 18 to May 6 was very slight, amounting to not more than three-tenths of a magnitude, and the maximum is consequently very roughly indicated for April 10.

Syrian Protestant College, Beirut, Syria, 1896 *Aug.* 4.

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[*] 3244, *S Pyxidis.* — Ed.

A NEW SHORT-PERIOD VARIABLE IN *GEMINI.*

$6^{h}\ 29^{m}\ 14^{s}$; $+15^{\circ}\ 24'.8$ (1900.0)

By EDWIN F. SAWYER.

I wish to announce that I have discovered the star numbered 949 in the Potsdam Photometric Catalogue to be a variable of short-period. Although its variability was established some six months ago, press of other matters has prevented a presentation of the facts until now. The magnitude of the star in the Potsdam Catalogue is given as $7^{M}.04$; this being the mean of two very accordant determinations, 1887 March 15, $7^{M}.03$, and 1891 March 12, $7^{M}.04$.

My observations in connection with the revision of the magnitudes in this Catalogue (now more than half completed) recorded 1895 March 14 and 23, found the star $7^{M}.02$ and $7^{M}.16$ respectively, and are also fairly accordant; their mean, $7^{M}.09$, differing but slightly from the Potsdam results. My observations having, however, been taken so closely together, it was deemed best to obtain one more during the present year, this, fortunately, being taken on March 9, when the star was estimated to be $7^{M}.49$. This large discordance from my previous results led to further observations of the star, which soon established its variability beyond doubt. The star was under observation until May 4, the observations numbering 32.

From a discussion of these observations, together with those made in 1895, I have adopted as the best attainable elements:

1895 March 14.28 Greenw. M.T. + $7^{d}.74$ E
= 1895 March $14^{d}\ 6^{h}\ 45^{m}$ Greenw. M.T. + $(7^{d}\ 17^{h}\ 46^{m})$ E

for the epoch of maximum. The minimum occurs earlier by $2^{d}.65$. The observed times of maxima and minima are given below. The column O − C is a comparison with the preceding elements.

E.	Observed Maxima Boston M.T.	wt.	O—C	E.	Observed Minima Boston M.T.	wt.	O—C
			d				d
0	1895 Mar. 13.86	1	−0.22	47	1896 Mar. 9.38	1	+0.17
1	22.23	1	+ .41	48	16.15	1	— .80
47	1896 12.36	2	+ .50	49	24.42	2	— .27
48	18.85	3	— .75	50	Apr. 1.80	3	+ .37
49	27.25	2	— .09	51	9.00	4	— .15
50	Apr. 3.69	4	— .39	52	17.03	1	+ .14
51	11.86	3	+ .04	53	25.01	1	+ .38
52	19.43	1	— .13	54	May 3.03	2	+0.66
53	27.32	1	+0.02				

The comparison-stars and the light-scale are

Star	1900.0 α	δ	P	S	Light scale
	h m s	° ′	M	M	
a = 948 Potsdam	6 29 9	+16 16.6	6.85	6.73	10.0
b = 941 "	6 26 57	+15 5.5	7.36	7.46	3.0
c = 956 "	6 30 44	+15 50.3	7.62	7.60	1.0

The characteristics of the light-fluctuations derived from the preliminary mean light-curve are a somewhat slow increase; a much slower decrease, with indications of a retardation about a day after maximum. The duration of increase is 2.65 days, and that of decrease 5.10 days.

Brighton, Mass., 1896 *Sept.* 21.

The readings of the light-curve give the following

Light-Tables

Time from Max.	L.	Mag.	Time from Max.	L.	Mag.
d			d		
−2.65	1.0	7.60	+1.25	6.5	7.04
2.50	1.1	7.59	1.50	6.3	7.06
2.25	1.2	7.58	1.75	5.9	7.10
2.00	1.4	7.56	2.00	5.5	7.14
1.75	1.7	7.53	2.25	5.1	7.18
1.50	2.3	7.47	2.50	4.7	7.22
1.25	3.2	7.38	2.75	4.2	7.27
1.00	4.4	7.26	3.00	3.7	7.32
0.75	5.6	7.14	3.25	3.2	7.37
0.50	6.8	7.02	3.50	2.6	7.43
−0.25	8.2	6.88	3.75	2.1	7.49
0.00	8.9	6.80	4.00	1.7	7.53
+0.25	8.6	6.83	4.25	1.5	7.55
0.50	7.6	6.93	4.50	1.3	7.57
0.75	6.9	7.00	4.75	1.1	7.59
+1.00	6.6	7.03	5.00	1.0	7.60
			+5.10	1.0	7.60

The range of variation is from $6^{M}.8$ to $7^{M}.6$.

The star is slightly colored, and its magnitude in the DM. is $7^{M}.3$.

EPHEMERIS OF MINOR PLANET (387),

BY JOHN H. OGBURN.

1896 Berlin M.T.	App. α	App. δ	log Δ	Aberr. Time
12 hours	h m s	° ′ ″		m s
Oct. 28	3 40 36.71	−7 15 39.1	0.3157201	16 58
29	3 39 47.55	−7 20 8.4		
30	3 38 57.64	−7 24 27.5		
31	3 38 7.06	−7 28 35.9		
Nov. 1	3 37 15.86	−7 32 33.6	0.3153546	16 57
2	3 36 24.11	−7 36 19.9		
3	3 35 31.85	−7 39 54.6		
4	3 34 39.14	−7 43 17.6		
5	3 33 46.05	−7 46 28.4	0.3158777	16 59
6	3 32 52.58	−7 49 26.7		
7	3 31 58.93	−7 52 12.4		
8	3 31 5.01	−7 54 45.4		
9	3 30 10.92	−7 57 5.7	0.3173089	17 2
10	3 29 16.73	−7 59 12.6		
11	3 28 22.48	−8 1 6.4		
12	3 27 28.23	−8 2 46.9		
13	3 26 34.03	−8 4 14.1	0.3196443	17 7
14	3 25 39.96	−8 5 27.6		
15	3 24 46.05	−8 6 27.5		
16	3 23 52.41	−8 7 13.8		
Nov. 17	3 22 58.95	−8 7 46.6	0.3228488	17 15
18	3 22 5.87	−8 8 5.5		
19	3 21 13.16	−8 8 10.8		
20	3 20 20.87	−8 8 2.4		
21	3 19 29.04	−8 7 40.3	0.3269060	17 25
22	3 18 37.74	−8 7 4.5		
23	3 17 47.01	−8 6 15.1		
24	3 16 56.87	−8 5 11.6		
25	3 16 7.39	−8 3 55.8	0.3317716	17 35
26	3 15 18.62	−8 2 26.4		
27	3 14 30.59	−8 0 43.6		
28	3 13 43.34	−7 58 47.1		
29	3 12 56.90	−7 56 36.9	0.3373933	17 50

Opposition Nov. 15, magnitude 10.5.

This ephemeris is based on my elements published in *A.J.*, 381. No account has been taken of perturbations; as the major planets are at a considerable distance it is likely that the error of the ephemeris due to this cause will be small.

Lehigh University, 1896 *Sept.* 28.

MAXIMA AND MINIMA OF LONG-PERIOD VARIABLES,

BY J. A. PARKHURST.

678. *U Persei.*

Since my last report (*A.J.*, XVI, 110) I have 10 observations from 1896 April 3 to Sept. 19, yielding a minimum, $11^{M}.6$ June 12. I have lately re-reduced all my observations, 116 in number, from 1893 Aug. 7 to the present time, using a revised light-scale, to ascertain whether or not they would confirm the conclusions reached by Mr. YENDELL, published in *A.J.* no. 383. My observations were continuous with the exception of a break from 1894 Aug. 8 to Nov. 15 (corresponding to the minimum of epoch 6), and include three maxima and three minima. They were reduced with the following light-scale:

	DM.	Mag. P.	Coordinates from Var. R.A.	Dec.
	°	M	′	′
d	53 440	7.4		
c	53 428	8.6		
e	54 438	8.7		
m		9.6	+21.9	−5.5
g		10.0	+ 3.8	+8.7
a		11.1	+ 1.8	−1.3
k		12.3	+ 2	+1

Normal points were formed from groups of five observations. It was found that these points all lay very close to a smooth curve, — the greatest divergence occurring in three out of the twenty-three points, being 0.1 mag. The curve had the following characteristics (the time being reckoned from the elements of CHANDLER'S Third Catalogue). A steady rise from a minimum, $11^{M}.6$, at −168 days, a stand-still at $8^{M}.0$, from −60 to −40 days, the middle of this stand-still agreeing exactly with YENDELL'S first crest; a rise to a maximum of $7^{M}.1$ at +7 days, then a steady and uninterrupted fall to minimum. If the stand-still be smoothed out, the maximum falls at 0 days. The following points in the curve are enough to show its peculiarities:

Days from max.	Before	After
0	7.1	
20	7.5	7.2
40	8.0	7.6
60	8.0	8.4
80	8.5	9.4
100	9.3	10.4
120	10.4	11.0
140	11.1	11.4
160	11.5	

There are two reasons why my maximum magnitude is $1^{M}.3$ greater than YENDELL'S estimates. My values for the comparison-stars used near that part of the curve are about $0^{M}.5$ brighter than his; and in addition, my eye, and the reflector which I use, cause me to estimate red stars uniformly brighter than he does. It will be noticed that my brightest comparison-star is $0^{M}.3$ fainter than the variable at maximum. This, together with the fact that the observations were nearly all made with the full aperture, 6.2 inches, would tend to mask the minor fluctuations, and thus render my results of less weight than YENDELL'S.

The curve at minimum is free from the above-mentioned irregularities, and thus better adapted to a determination of the period. The intervals between the minima which I have observed are 309 and 323 days. (See *A.J.*, XIV, 6 and XV, 177.) The mean, 316 days, is 2 days less than CHANDLER'S period. The above minima were possibly overlooked in the preparation of the Third Catalogue.

659. *X Cassiopeae.*

My watch on this star has been uninterrupted since the maximum, 1895 Oct. 10; 33 observations being secured up to the present time. It fell rather quickly from $9^{M}.5$ to a minimum, $12^{M}.2$ 1896 Feb. 23; then rose more slowly to $10^{M}.0$ at the last comparison, Sept. 25. Its intense red color at times renders the comparisons uncertain, the apparent light-curve being a succession of small saw teeth, the mean divergence of the observed points from a smooth curve being $0^{M}.2$, the extreme $0^{M}.6$.

The comparison-stars are as follows:

	DM.	Mag. P.	Coordinates from Var. R.A	Dec.
	°	M	′	′
g	58 334	8.6	+1.1	−3.7
e		9.9	−1.6	+0.7
c		10.2	−3.0	+1.4
f		10.3	+0.9	−0.3
d		10.6	−2.6	+0.4

4315. *R. Comae.*

This star was looked for, without being seen, from 1896 May 28 to June 30. It was first seen July 6, and the following seven observations, ending Aug. 26, show a rapid increase from $12^{M}.3$, when first seen, to $10^{M}.0$ July 26; then a more gradual rise to $9^{M}.25$ when lost in the western twilight. Under these circumstances it is impossible to tell whether the maximum was past or not; if so, it could not have been much before the last date.

5583. *X Librae.*

Mr. HENRY M. PARKHURST requested me to look for this star in August, to decide, if possible, whether its period, as he suspected, is two-thirds that given in the Third Catalogue. If so the minimum would occur Aug. 8, and any rise, if detected, would decide in favor of the shorter period. The star was looked for without being seen on the following dates:

	Limit		Limit
	M		M
1896 Aug. 3	12.5	1896 Aug. 26	11.8
10	12.4	31	10.8
17	10	Sept. 7	10.5
24	11.8		

These observations were, therefore, not at all decisive, as even if the minimum had been passed Aug. 8, it would probably have been fainter than 12^{M} Sept. 1, and invisible.

5601. *S Ursae minoris.*

This star has been continuously observed since the maximum reported in *A.J.* XVI, 110. I have 13 observations between 1896 April 13 and Sept. 7. The star was nearly stationary in light at 9^{M}.8 till May 28; then followed a sharp decline to a well marked minimum, 11^{M}.4, June 27; then a slower rise to 9^{M}.3 at the last observation.

The positions of the following comparison-stars were measured with the filar micrometer:

		Mag.		Coordinates from Var.	
	DM.	DM.	P.	R.A.	Dec.
	°	M	M	'	'
f	78 518	8.3	7.8	−1.3	−18.1
e	78 519	9.0	8.8	+4.2	−19.3
b	79 467	9.4	10.6	0.0	− 1.2
d			10.2	+0.7	+ 2.3
k			10.4	−7.2	−11.2
l			11.4	+4.3	+ 3.4
m			12.0	−0.9	+ 1.0

5830. *R Scorpii.*

This star was about stationary in light at 10^{M}.3 from the first observation, 1896 May 28 to June 10; then it fell quickly to 12^{M} when last seen, July 6. I have 7 observations in all. A maximum, 10^{M}.3, is indicated June 4, but it may have occurred earlier.

5831. *S Scorpii.*

This star was first seen at 11^{M}.3 1896 May 28. It rose rapidly to a maximum, 9^{M}.8 June 26. It was 10^{M}.5 July 11; not seen July 21, limit 10^{M}.5; not seen Aug. 3, limit 12^{M}. I have 10 observations.

7085. *RT Cygni.*

My observations, 11 in number, began 1896 May 28 and ended Sept. 7. The star rose steadily from 9^{M}.0 to a maximum, 7^{M}.0 July 17. The fall was a trifle slower than the rise. It was 9^{M}.0 at the last observation.

7118. *X Aquilae.*

I have 8 observations of this star, between 1896 June 17 and Sept. 7. When first seen it was 10^{M}.2. It rose slightly and then fell steadily to 12^{M}.3 at the last observation. A maximum, 10^{M}.1, is indicated for June 29, though it may have occurred earlier, as my watch on the star began too late to definitely decide. My comparison-stars are as follows:

		Mag.		Coordinates from Var.	
	DM.	DM.	P.	R.A.	Dec.
	°	M	M	'	'
k	3 4170	8.7	8.3	− 3.9	−11.7
t			9.7	−14.4	+ 1.3
l			9.8	−21.9	+ 4.7
d			9.8	− 3.2	+ 8.2
e			10.0	− 7.0	+13.5
c			10.9	+ 5.7	+ 1.8
r			11.4	− 3.4	− 5.8
s			12.3	− 0.8	− 2.3

7242. *S Aquilae.*

My observations began 1896 June 27, when the star was 9^{M}.8. It fell quickly to a minimum, 11^{M}.0 July 22, then rose more slowly to 9^{M}.7 Sept. 7. I have 11 observations between the above dates. My comparison-stars are as follows:

		Coordinates from Var.	
	Mag.	R.A.	Dec.
	M	'	'
a	9.2	+0.2	−1.5
e	9.6	+1.9	−8.3
b	10.1	−3.1	+2.9
c	10.5	+0.5	−4.7
d	11.7	−2.0	−1.3

The star *a* is DM. 15°4079.

ECLIPSES AND CHRONOLOGY: A FINAL REJOINDER,

By W. T. LYNN.

Although Prof. STOCKWELL no longer quotes as an authority for the circumstances of the last battle of THEODOSIUS a historian (AMMIANUS MARCELLINUS), who died some years before it took place, he still endeavors to maintain his point that it occurred late in November 393, at the time of the eclipse. SOCRATES gives the date as Sept. 6; but Prof. STOCKWELL thinks that, as THEODOSIUS left Hadrianople in the middle of June, he could not have reached the neighborhood of Aquileia by the first week in September; and he compares the time occupied by NAPOLEON in advancing from Dresden to Moscow, apparently forgetting not only that NAPOLEON was proceeding, the greater part of the time, through a hostile country in which his march was opposed (that of THEODOSIUS was not), but that he made, from political reasons, long delays, particularly at Wilna. On the other hand, I say that between the end of November, when the eclipse took place, and early in January, when THEODOSIUS died, it would have been quite impossible for HONORIUS to have received a message from his father at Constantinople, and to travel from there to him; the details of the journey are mentioned by CLAUDIAN. As to the red, or rather reddened snow of that poet, GIBBON remarks in a note that "his wit is intolerable." But "*Alpinae nives*" do always exist; and a tempestuous north wind might bring some down from the mountains at almost any time.

Blackheath, 1896 *Aug.* 6.

COMET *d* 1896 (*GIACOBINI*).

Inevitable delays in the issue of this number have prevented the publication of the earlier elements and ephemerides of this comet, until the latter have expired.

Under date of September 10 elements were sent by Mr. F. H. **Seares** of the Students' Observatory of the University of California, computed by him and Mr. R. T. **Crawford**, from observations made at the Lick Observatory by Prof. **Hussey**, September 5, 6, 7, together with an ephemeris extending from Sept. 12 to 24; followed subsequently by a continuation until Oct. 22.

$$T = \text{Oct. } 10.3415 \text{ Greenw. M.T.}$$

$$\left.\begin{array}{rl} i = & 9^\circ\ 6'\ 8'' \\ \Omega = & 195\ 33\ 58 \\ \omega = & 154\ 47\ 45 \end{array}\right\} \text{M. Equin. } 1896.0$$

$$\log q = 1.112731$$

The corresponding coordinates for the equator were

$$\begin{aligned} x &= [0.045998] \sin(\ 80^\circ\ 10'\ 31''.3 + v) \sec^2 \tfrac{1}{2} v \\ y &= [0.032003] \sin(319\ 32\ 17.7 + v) \sec^2 \tfrac{1}{2} v \\ z &= [9.155829] \sin(359\ 22\ 51.5 + v) \sec^2 \tfrac{1}{2} v \end{aligned}$$

Mr. **Perrine** of the Lick Observatory sent on Sept. 11 elements from the same observations.

$$T = \text{Sept. } 27.1220 \text{ Greenw. M.T.}$$

$$\left.\begin{array}{rl} i = & 6\ 55'\ 32'' \\ \omega = & 160\ 51\ 16 \\ \Omega = & 191\ 37\ 42 \end{array}\right\} \text{M. Equin. } 1896.0$$

$$\log q = 0.01370$$

which represent the middle observation thus:

$$(\text{O}-\text{C}) \quad \Delta\lambda \cos\beta = 0'' \quad , \quad \Delta\beta = -1''.$$

With these was an ephemeris from Sept. 12 to Oct. 2.

COMET *e* 1896 (*SPERRA*).

Prof. **Hussey** has sent elements computed from his observations of Sept. 6, 8 and 11:

$$T = \text{July } 10.41828 \text{ Greenw. M.T.}$$

$$\left.\begin{array}{rl} \omega = & 40^\circ\ 17'\ 38''.0 \\ \Omega = & 150\ 59\ 47.1 \\ i = & 88\ 24\ 46.4 \end{array}\right\} \text{M. Equin. } 1896.0$$

$$\log q = 0.055430$$

Residuals for middle place,

$$\Delta\lambda \cos\beta = +0''.3 \quad , \quad \Delta\beta = +0''.8.$$

Mr. F. H. **Seares** has sent elements and ephemeris computed by himself and Mr. R. T. **Crawford** from the same observations.

$$T = \text{July } 10.6427 \text{ Greenw. M.T.}$$

$$\left.\begin{array}{rl} \omega = & 40^\circ\ 38'\ 53'' \\ \Omega = & 151\ \ 1\ \ 6 \\ i = & 88\ 25\ 12 \end{array}\right\} \text{M. Equin. } 1896.0$$

$$q = 1.139897$$

Residuals, O−C, $\Delta\lambda \cos\beta = -0''.7$, $\Delta\beta = +3''.7$.

$$\begin{aligned} x &= [9.998811] \sin(309^\circ\ 46'\ 23''.7 + v) \sec^2 \tfrac{1}{2} v \\ y &= [9.843275] \sin(174\ \ 1\ 21.4 + v) \sec^2 \tfrac{1}{2} v \\ z &= [0.021276] \sin(\ 52\ 38\ 43.8 + v) \sec^2 \tfrac{1}{2} v \end{aligned}$$

Ephemeris for Greenwich Mean Midnight.

1896	α	δ	log ρ	Br.
	h m s	° ′		
Sept. 14.5	14 44 58	+53 53.5	0.2250	0.91
18.5	15 11 38	52 37.1	0.2260	0.86
22.5	15 37 0	51 3.5	0.2284	0.81
26.5	16 0 51	+49 15.2	0.2323	0.76

OBSERVATIONS OF COMET *e* 1896 (*SPERRA*),

MADE AT THE LICK OBSERVATORY,

By WILLIAM J. HUSSEY.

1896 Mt. Hamilton M.T.	*	No. Comp.	☄ − *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Sept. 6 11 56 34	1	6 , 6	−2 8.57	+1 26.0	13 51 44.06	+55 25 1.5	9.742	0.674
8 9 6 48	2	9*d* , 9	−0 13.06	+1 22.6	14 4 54.58	55 9 35.0	9.914	0.548
11 8 35 9	4	13 , 6	+0 15.36	+3 50.4	14 25 39.10	+54 35 42.7	9.900	0.628

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	13 53 51.60	+1.03	+55 23 39.7	−4.2	Krueger, Helsingfors-Gotha A.G. Catal., 7767
2	14 5 6.67	+0.97	+55 8 16.4	−4.0	$10\frac{1}{2}$ᴹ ± connected with *3
3	14 6 36.99	+0.93	+55 6 26.8	−3.9	Krueger, Helsingfors-Gotha A.G. Catal., 7856
4	14 25 22.84	+0.90	+54 31 55.7	−3.4	$14\frac{1}{2}$ᴹ ± connected with *5
5	14 23 36.28	+0.91	+54 26 0.2	−3.5	Rogers, Cambridge A.G. Catal., 4529

The first and second observations were made with the 12-inch and the third with the 36-inch telescope. The comet is faint and diffuse, and difficult to observe accurately, especially with the 12-inch telescope. Mr. **Perrine** assisted me in making the first observation.

Mt. Hamilton, Cal., 1896 *Sept.* 14.

NOTATION AND NOMENCLATURE OF ASTEROIDS.

The numeration of recently discovered small planets has been assigned as follows by the Berlin *Rechen-Institut*:

Planet	Discoverer	Date	No.	Planet	Discoverer	Date	No.
CE	Charlois,	1895 Dec. 9	(409)	*CN*	Charlois,	1896 Jan. 16	(414)
CH	"	1896 Jan. 7	(410)	*CO*	Wolf,	Feb. 7	(415)
CJ	"	Jan. 7	(411)	*CS*	Charlois,	May 4	(416)
CK	Wolf,	Jan. 7	(412)	*CT*	Wolf,	May 6	(417)
CL	"	Jan. 7	(413)				

CM (Charlois, Jan. 16) proved to be identical with (332) *Siri*. The asteroids of 1896, *CP*, *CQ*, *CR*, have not been sufficiently observed to permit determination of their orbits.

The planet (352) = 1893 *B* has received from its discoverer, Prof. Wolf, the name *Gisela*.

NEW ASTEROIDS.

Prof. Kreutz has transmitted notice of the discovery by Wolf of a small planet, *CU*, Sept. 3, to which are to be added five more, found upon a plate of Sept. 7.

	M		h m s				h m s		° ′		s ′
CU	12	Sept. 3	10 42	Heidelberg	M.T	$\alpha =$	22 45 28	$\delta =$	+2 32	Daily motion,	−40 and 4 southward.
CV	12	Sept. 7	10 39	"	"		22 49 52		+5 30	" "	−52 " 5 "
CW	11	"	"	"	"		23 9 0		+1 19	" "	−56 " 6 "
CX	11	"	"	"	"		23 13 40		−0 23	" "	−52 " 5 "
CY	12½	"	"	"	"		22 44 28		+2 4	" "	−40 " 5 "
CZ	12½	"	"	"	"		23 2 28		+0 25	" "	−40 " 10 "

NOTE FROM DR. L. SWIFT.

On the evening of Sept. 20, I turned to look out of the window, some 20 feet distant, to see the sun descend behind a spur of the Sierra Madre range, about one-quarter of its diameter having disappeared. Instantly I noticed a luminous object about one degree above the sun. Thinking it was caused by refraction from a knot in the glass, I moved my head, but found the object remained stationary. Going out on the veranda the object was seen more distinctly. At first it occurred to me that it might be a small fire on the mountain, but this idea was quickly dispelled, as one-half of the sun's disk was still above the mountain, and the object still higher. Seizing an opera-glass I saw that it had a very much fainter companion some 30′ north, but it could not be seen without the glass. In about four minutes after the sun had set the two objects also disappeared behind the mountain.

Both objects were seen by some fifteen people. Yesterday morning I attempted to refind the bright one with the 4½-inch comet-seeker, but failed, as the sun is not visible from the Observatory until 15° above the horizon. Last evening I began a search with the comet-seeker with the sun 10° in altitude, but nothing was seen until fully one-half of the sun had disappeared when I caught sight of it, but its faintness surprised me, for it was less bright through the telescope than with the naked eye the previous evening, though it is possible, and, perhaps probable, that it was the companion that was seen.

I only saw it for 5 seconds, and rushing into the Observatory to get a view of it with the 14-inch which I had previously set to near the place, I found the eye-piece was beyond my reach. Repairing to the comet-seeker I found both sun and object had set. I estimate that the object disappeared simultaneously with the sun's upper limb.

The only thing that perplexes me about this strange affair is, that the sun, object, and companion, were not in line, but must have deviated from it by 30° or more.

Echo Mountain, Cal., 1896 *Sept.* 22.

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THE SECULAR PERTURBATIONS OF *MERCURY* ARISING FROM THE ACTION OF *JUPITER*,

By ERIC DOOLITTLE.

In applying Dr. G. W. Hill's modifications of Gauss's method of computing secular perturbations to the case of two planets in which the ratio of the semi-major axes $\left(\frac{a'}{a}\right)$ is very great, it will be found that the approximate tests, furnished by comparing the sums of the functions corresponding to the odd and even points of division of the orbit, are in some cases inapplicable. This at first occurs with the angle ϵ, in consequence of the term a'^2e'; the functions immediately dependent upon this angle will also not satisfy the test, but the disagreement will nearly disappear as the work progresses.

In this case, also, the determination of the roots G' and G'' by Dr. Hill's first method will require many approximations, since g will not be small in comparison with $h(h-l)$, while if the second method be employed, the angle θ will be so nearly equal to 90° as also to render their exact determination difficult. In the following computation the method of proceeding has been therefore very slightly modified.

The elements are adopted from Dr. Hill's "*New Theory of Jupiter and Saturn*" (pages 192 and 558):

Mercury

$$\begin{aligned}
\pi &= 75^\circ\ 7'\ 13''.62\\
i &= 7\ \ 0\ \ 7.71\\
\Omega &= 46\ 33\ \ 8.63\\
e &= 0.20560476\\
n &= 5381016''.260\\
\log a &= 9.5878217\\
m &= \tfrac{1}{5000000}
\end{aligned}$$

Jupiter

$$\begin{aligned}
\pi' &= 11^\circ\ 54'\ 31''.67\\
i' &= 1\ 18\ 42.10\\
\Omega' &= 98\ 56\ 19.79\\
e' &= 0.04825511\\
n' &= 109256''.626\\
\log a' &= 0.7162374\\
m' &= \tfrac{1}{1047.879}
\end{aligned}$$

Epoch 1850.0. Greenwich Mean Time.

The preliminary constants were found to have the following values:

$$\begin{aligned}
I &= 6^\circ\ 17'\ 15''.31\\
II &= 218\ \ 5\ 54.72\\
II' &= 154\ 49\ 24.01\\
K &= 63\ \ 8\ 32.52\\
K' &= 63\ 24\ 30.76
\end{aligned}
\qquad
\begin{aligned}
\log k &= 9.9995281\\
\log k' &= 9.9978563\\
\log c &= 8.7995614\\
c &= 0.063032014
\end{aligned}$$

The roots G, G' and G'' were determined as follows. The first approximation to G was obtained by the formulae of Dr. Hill's second method, the exact value being found by successive applications of the equation

$$G = h - \frac{g}{G(G-l)}$$

G' and G'' were then obtained from the equations

$$G' = \frac{A-C-G}{2} \pm \tfrac{1}{2}\sqrt{(A-C-G)^2+\frac{4g}{G}}$$

$$G'' = \frac{-A+C+G}{2} \pm \tfrac{1}{2}\sqrt{(A-C-G)^2+\frac{4g}{G}}$$

and their values verified by

$$G' = l + \frac{g}{G'(h-G')}$$

$$G'' = \frac{g}{(l+G'')(h+G'')}$$

The double values give rise to no ambiguity, for since G is greater than $(A-C)$ the positive value of the radical must be taken to render G' and G'' positive.

The results are given in the following tables

E	log	v	A	ϵ	log B	log p	log q^2	log r
0	9.487 8584	0 0 0.00	27.233 40536	35 2 1.56	0.393 9342	0.956 9744	1.906 0787	n2.859 0255
30	9.502 6623	36 32 7.50	27.143 56714	57 36 19.89	0.283 1381	0.955 5360	1.907 5531	n2.861 2693
60	9.540 7098	70 50 41.41	27.068 79996	87 39 20.52	0.409 7322	0.954 3353	1.908 7576	n2.863 1053
90	9.587 8217	101 51 53.65	27.031 45602	141 23 7.55	9.911 3562	0.953 7343	1.909 3259	n2.863 9813
120	9.630 3194	129 46 44.60	27.042 70097	210 27 49.77	9.997 1055	0.953 9154	1.909 1137.	n2.863 6644
150	9.658 9887	155 27 29.02	27.098 36244	249 44 50.99	0.197 9120	0.954 8104	1.908 2286	n2.862 3001
180	9.669 0267	180 0 0.00	27.181 20741	275 34 13.04	0.336 4147	0.956 1392	1.906 9519	n2.860 3153
210	9.658 9887	204 32 30.98	27.267 87830	297 11 11.56	0.423 4408	0.957 5250	1.905 6175	n2.858 2431
240	9.630 3194	230 13 15.40	27.336 31108	317 13 34.31	0.473 9392	0.958 6161	1.904 5315	n2.856 4772
270	9.587 8217	258 8 6.35	27.370 48776	336 35 32.85	0.496 0583	0.959 1600	1.903 9112	n2.855 7263
300	9.540 7098	289 9 18.59	27.362 40999	355 42 17.86	0.491 8723	0.959 0315	1.904 0133	n2.855 8448
330	9.502 6623	323 27 52.50	27.313 08297	14 57 10.82	0.459 7394	0.958 2461	1.904 7799	n2.857 0389
Σ_1			163.224 83480	1281 39 17.06	1.802 6981	*54.282 2142	*483.871 398	
Σ_2			163.224 83460	1097 28 13.66	1.771 3448	*54.282 2141	*483.871 348	

E	θ_1	log g	h	l	G	G'	G''	θ_2
°	° ' "							
0	− 88 49 5	9.105 3430	27.006 742	+0.163 630	27.066 566	0.188 801	0.024 995	5 6 8.07
30	− 89 2 45	9.218 9132	27.007 491	+0.073 044	27.007 263	0.123 075	0.019 804	4 35 5.15
60	− 89 19 0	9.018 2984	27.007 569	−0.001 801	27.007 426	0.061 321	0.062 980	3 53 7.75
90	− 89 39 30	8.212 7520	27.006 899	−0.038 475	27.006 877	0.011 983	0.050 435	2 45 10.71
120	− 89 41 40	8.203 7786	27.006 246	−0.026 577	27.006 224	0.014 441	0.040 995	2 35 41.32
150	− 89 11 43	9.139 9542	27.006 455	+0.028 875	27.006 265	0.087 484	0.058 419	4 12 38 17
180	− 88 41 46	9.467 6796	27.007 536	+0.110 638	27.007 132	0.173 639	0.062 597	5 21 37.00
210	− 88 20 11	9.544 1580	27.008 599	+0.196 247	27.008 116	0.248 823	0.052 092	6 3 41.63
240	− 87 48 4	9.411 3146	27.008 698	+0.264 581	27.008 341	0.297 071	0.032 133	6 20 5.30
270	− 88 19 32	8.989 8466	27.007 728	+0.299 728	27.007 593	0.311 476	0.011 613	6 16 40.56
300	− 88 22 22	7.532 1816	27.006 562	+0.292 816	27.006 557	0.293 250	0.000 430	5 59 8.38
330	− 88 35 32	8.542 3694	27.006 176	+0.243 874	27.006 128	0.249 105	0.005 182	5 34 4.63
Σ_1	−532 41 57		162.043 353	0.803 287	162.042 246	1.028 523	0.224 130	29 15 47.82
Σ_2	−533 9 13		162.043 348	0.803 293	162.042 242	1.031 946	0.227 545	29 26 50.85

E	log 𝔛	log 𝔛′	log 𝔜	log N	log P	log Q	log V	log (J_1-G'')
0	0.002 5877	0.276 4500	0.179 9707	6.418 3196	3.831 0274	5.166 4192	5.165 9174	1.429 4747
30	0.002 0887	0.275 7852	0.179 2229	6.446 8140	3.858 0378	5.193 7562	5.192 7566	1.426 5919
60	0.001 4995	0.275 0001	0.178 3398	6.521 9986	3.932 0091	5.267 8436	5.266 5795	1.426 7774
90	0.000 7524	0.274 0043	0.177 2196	6.615 7906	4.025 2257	5.360 7256	5.359 7128	1.429 3015
120	0.000 6684	0.273 8923	0.177 0937	6.700 9450	4.110 5921	5.445 9161	5.445 0927	1.431 2326
150	0.001 7613	0.275 3489	0.178 7322	6.758 9559	4.169 4988	5.505 2851	5.504 1125	1.431 1761
180	0.002 8566	0.276 8082	0.180 3735	6.780 0058	4.191 8462	5.527 8954	5.526 6396	1.429 4747
210	0.003 6449	0.277 8582	0.181 5544	6.760 9474	4.174 1434	5.510 1707	5.509 1259	1.427 3339
240	0.003 9929	0.278 3216	0.182 0755	6.704 4320	4.118 7250	5.454 4932	5.453 8485	1.426 2263
270	0.003 9213	0.278 2263	0.181 9683	6.619 8775	4.034 7585	5.370 1732	5.369 9402	1.427 2508
300	0.003 5638	0.277 7502	0.181 4329	6.525 5910	3.940 3890	5.275 5478	5.275 5392	1.429 9356
330	0.003 0827	0.277 1094	0.180 7123	6.448 9104	3.862 9284	5.198 0770	5.197 9730	1.431 4585
Σ_1	0.015 1689	1.658 2224	1.079 2861	9.651 2920	4.124 5888	2.138 1153	2.133 6169	*161.067 41
Σ_2	0.015 2513	1.658 3323	1.079 4097	9.651 2958	4.124 5926	2.138 1878	2.133 6210	*161.067 61

E	log J_2	log J_3	log F_2	log F_3	log R_0	log S_0	log W_0	$R_0 \sin v$ $+S_0 (\cos v+\cos E)$
0	n8.946 8592	n0.159 5246	n0.265 7824	9.103 8763	6.112 2103	n4.405 8966	n5.323 6713	−0.000 005 09245
30	n7.613 5859	n0.367 9327	n0.322 5675	8.702 7387	6.131 3612	n4.198 5735	n5.560 2547	+0.000 077 92118
60	9.209 8603	n0.397 6712	n0.222 2601	n8.728 6511	6.206 6851	4.195 5690	n5.664 6812	+0.000 153 33585
90	9.266 3508	n0.277 7676	n9.819 4869	n8.715 6177	6.307 9843	4.547 5195	n5.638 0704	+0.000 198 16106

* The corresponding numbers have been added.

E	log J_2	log J_3	log F_2	log F_3	log R_0	log S_0	log W_0	$R_0 \sin r + S_0 (\cos r + \cos E)$
120	8.629 0725	n9.836 5490	9.815 0002	8.889 8136	6.399 0613	4.307 2311	n5.279 3630	+0.000 190 31365
150	n9.161 8624	9.906 0919	0.283 0880	9.381 0929	6.457 2346	n4.255 0266	5.416 2047	+0.000 122 22497
180	n9.417 8029	0.338 5237	0.446 9507	9.466 2129	6.473 5880	n4.647 9795	5.867 8507	+0.000 008 89221
210	n9.391 7932	0.487 0918	0.485 1899	9.260 8206	6.448 4334	n4.530 9984	5.997 4087	−0.000 110 61496
240	n9.032 5287	0.509 9037	0.418 7682	8.970 6349	6.388 8721	3.582 9583	5.964 3318	−0.000 188 59570
270	8.830 6376	0.420 3771	0.208 0342	n8.895 5979	6.307 7209	4.523 2280	5.789 7173	−0.000 199 45173
300	9.132 5664	0.153 2419	9.479 2017	n8.399 0336	6.221 6777	4.450 5550	5.428 4275	−0.000 155 03995
330	8.429 8249	n8.838 6881	n9.984 2956	8.941 0842	6.149 3410	n3.445 6244	n4.010 4696	−0.000 084 43003
Σ_1		*2.210 0104			*0.001 250 0899	*−0.000 000 189 983	+0.000 106 39725	+0.000 003 81361
Σ_2		*2.210 0109			*0.001 250 0899	*−0.000 000 189 989	+0.000 106 28675	+0.000 003 81349

E	$-R_0 \cos r + S_0 \left(\frac{r}{a} \sec^2 \varphi + 1 \right) \sin r$	$W_0 \cos u$	$W_0 \sin u$	$-2 \frac{r}{a} R_0$	$\log \frac{1}{a} \sin \mathrm{E}\, R^{(a)}$	$\log \frac{1}{a} S^{(a)}$
0	−0.000 129 49124	−0.000 018 505 013	−0.000 010 075 877	−0.000 205 73445	. . . .	n4.918 0382
30	−0.000 110 47546	−0.000 015 293 859	−0.000 032 953 015	−0.000 222 44969	6.327 6689	n4.695 9112
60	−0.000 049 94118	+0.000 007 556 597	−0.000 045 582 053	−0.000 288 80400	6.603 5059	4.654 8592
90	+0.000 048 84221	+0.000 028 185 071	−0.000 033 078 773	−0.000 406 45673	6.720 1626	4.959 6978
120	+0.000 163 72520	+0.000 017 684 089	−0.000 007 020 516	−0.000 552 82671	6.706 2725	4.676 9120
150	+0.000 259 01646	−0.000 026 009 473	−0.000 001 830 673	−0.000 675 19875	6.497 2159	n4.596 0379
180	+0.000 297 56923	−0.000 064 784 149	−0.000 035 274 618	−0.000 717 50180	. . . .	n4.978 9528
210	+0.000 258 59897	−0.000 059 670 973	−0.000 079 503 145	−0.000 661 65318	n6.488 4147	n4.872 0097
240	+0.000 156 01907	−0.000 017 909 313	−0.000 090 357 562	−0.000 510 00750	n6.696 0833	3.952 6389
270	+0.000 035 08579	+0.000 017 710 220	−0.000 059 019 459	−0.000 406 21028	n6.719 8992	4.935 4063
300	−0.000 059 82940	+0.000 019 842 790	−0.000 018 040 859	−0.000 298 94808	n6.618 4985	4.909 8452
330	−0.000 113 01587	−0.000 001 014 512	+0.000 000 141 991	−0.000 231 85401	n6.345 6517	n3.942 9621
Σ_1	−0.000 378 05168	−0.000 056 114 999	−0.000 206 351 485	−0.002 603 82254	*−0.000 002 30582	*+0.000 000 484 5000
Σ_2	−0.000 378 05210	−0.000 056 093 526	−0.000 206 243 074	−0.002 603 82263	*−0.000 002 36831	*+0.000 000 497 5249

* The corresponding numbers have been added.

The usual test equations have been applied, and the work was also carried twice through from the beginning as a further check. It may be remarked that in the computation of the perturbations of *Mercury* by *Mars* the discordances of the sums of the functions from log P to the end were somewhat greater than here shown when the orbit was divided into twelve parts, but when the number of points of division was increased to twenty-four, the values of Σ_1 and Σ_2 became practically indentical.

A further test of R_0 and S_0 is stated by Mr. R. T. A. INNES (*Monthly Notices of the Royal Astronomical Society*, vol. LII, p. 80). It arises from the circumstance that, since $\left[\frac{da}{dt}\right]_{00} = 0$, we must have

$$\sin q \,.\, \tfrac{1}{2} A_1^{(s)} + \cos q \,.\, B_0^{(c)} = 0\,.$$

Upon substituting the values, there is obtained

$$\sin q \; \tfrac{1}{2} A_1^{(s)} + \cos q \,.\, B_0^{(c)} = +0.000,000,000.000,73.*$$

If m' is left indefinite, the resulting values of the differential coefficients are the following:

$$\begin{array}{lrl}
 & & \text{log coeff.} \\
\left[\frac{de}{dt}\right]_{00} = & +\quad 3''.3471\, m' & p0''.5246632 \\
\left[\frac{d\chi}{dt}\right]_{00} = & +1613.81 \quad m' & p3.2078521 \\
\left[\frac{di}{dt}\right]_{00} = & -\quad 51.4118\, m' & n1.7110881 \\
\left[\frac{d\Omega}{dt}\right]_{00} = & -1550.81 \quad m' & n3.1905591 \\
\left[\frac{d\pi}{dt}\right]_{00} = & +1602.24 \quad m' & p3.2047281 \\
\left[\frac{dL}{dt}\right]_{00} = & -2312.29 \quad m' & n3.3640422
\end{array}$$

If we adopt the mass of *Jupiter* given above,

$$m' = (1 \div 1047.879),$$

we obtain

---

* The residuals in the case of the computations with *Mars* on *Mercury* and the *Earth* on *Mercury* were,

With *Mars*,	+0.000,000,000,10
With the *Earth*,	−0.000,000,000,16

$$\left[\frac{de}{dt}\right]_{00} = +0{''}.00319113$$

$$\left[\frac{d\lambda}{dt}\right]_{00} = +1.540072$$

$$\left[\frac{di}{dt}\right]_{00} = -0.0490656$$

$$\left[\frac{d\Omega}{dt}\right]_{00} = -1.479953$$

$$\left[\frac{d\pi}{dt}\right]_{00} = +1.529034$$

$$\left[\frac{dL}{dt}\right]_{00} = -2.206638$$

If we adopt for m' the value assumed by LeVerrier, viz: $m' = 0.00095238$ (*Annales de l'Observatoire de Paris*, Tome V, pages 6, 7, 19), the results from the two methods may be compared as follows:

	Method of Gauss	Method of LeVerrier
$\left[\frac{de}{dt}\right]_{00} =$	$+0{''}.0031877$	$+0{''}.00319$
$\left[\frac{di}{dt}\right]_{00} =$	-0.0489664	-0.04897
$\left[\frac{d\Omega}{dt}\right]_{00} =$	-1.47696	-1.47699
$\left[\frac{d\pi}{dt}\right]_{00} =$	$+1.52594$	$+1.5259$
$\left[\frac{dL}{dt}\right]_{00} =$	-2.20218	-2.2034

The Flower Observatory, Univ. of Penna., 1896 *Sept.* 16.

ON SAWYER'S NEW VARIABLE IN *GEMINI*.

By PAUL S. YENDELL.

I began observing this star at Mr. Sawyer's request, early in April of the present year. It was then rather far west, and owing to unfavorable weather and increasing twilight, I was able to secure only eight observations, which did not appear to me to be in themselves sufficiently decisive to warrant a confirmation.

A comparison of these observations with Mr. Sawyer's, published in this Journal, p. 3 of the current volume, results, in spite of the meagreness of the material, in a distinct confirmation of the star's variability and type. The light-range observed, from $6^{M}.75$ to $7^{M}.50$, corresponds very nearly with Mr. Sawyer's, and the two minima, which were observed on a dark sky, fall very near his computed dates. The comparison-stars used were the same as his.

My observations indicate three minima, and there are three single observations near maximum.

The minima are as follows:

		M	
1896 April	9.2	7.35	2 obs.
	15.4	7.33	1 "
May	1.2	7.50	2 "

The observations near maximum are,

		M
1896 April	5.4	6.4:
	10.3	6.75
	20.35	6.75

Dorchester, Mass., 1896 *Oct.* 7.

ON THE VARIABILITY OF DM. 27°2772 AND 4°4332.

By PAUL S. YENDELL.

DM. 27°2772.

$\alpha = 17^{h}\ 4^{m}\ 58^{s}.4\quad,\quad \delta = +27°\ 14'.3\quad (1855)$

The variability of this star is announced by Anderson, *Astronomische Nachrichten*, no. 3366.

I have ten observations of it, from 1896 Aug. 25 to Sept. 23, showing a regular decline from $8^{M}.9$ to $9^{M}.6$. The star is variable.

DM. 4°4332.

$\alpha = 19^{h}\ 57^{m}\ 23^{s}.0\quad,\quad \delta = +4°\ 22'.9\quad (1855)$

This is one of the list of *Missing Durchmusterung Stars*, published by Chandler on the last page of his Third Catalogue.

I looked for it 1896 Aug. 30, and found an 11^{M} star in its apparent place. Having no means of verifying its position, I could not certainly identify it. This, however, has been done at my request by Mr. J. A. Parkhurst, who has kindly communicated his results by letter.

I have observations as follows:

	M		M
1896 Aug. 30	11.5	1896 Sept. 11	11.4
Sept. 4	11.5	23	11.3*
7	11.5		

* Bright moonlight.

Mr. Parkhurst's estimate on Sept. 19 was $11^{M}.1$.

The apparent increase shown by my observations is altogether uncertain, as the star is far too faint in my telescope for trustworthy comparison, though readily seen. Its variability seems probable, but this depends greatly on the character of Dr. Chandler's observations, of which I have no knowledge.

It was certainly observed at Bonn, 1855 July 26, as $9^{M}.5$ (*Bonn Observations*, Vol. VI).

Dorchester, Mass., 1896 *Sept.* 23.

ELLIPTIC ELEMENTS AND EPHEMERIS OF COMET *d* 1896 (*GIACOBINI*),

By Rev. GEO. M. SEARLE.

The following elements were obtained from the observation at Mt. Hamilton Sept. 5, at the U.S. Naval Observatory Sept. 9, and at Mt. Hamilton Sept. 28.

$$
\begin{aligned}
T &= \text{Nov. } 2.5242 \text{ Greenw. M.T.}\\
\Omega &= 196^\circ\ 14'\ 30''\\
\omega &= 144\ \ 8\ 17\\
i &= 10\ 58\ 13
\end{aligned}
\Bigg\} \ 1896.0
$$

$$
\begin{aligned}
\varphi &= 28\ 43\ 52\\
\log a &= 0.428573
\end{aligned}
$$

Period, 1605 days.

For the middle place (O−C), $\Delta\lambda = +6''$, $\Delta\beta = 0''$.

It did not seem worth while to obtain a closer approximation, on account of the unavoidable inaccuracy of single observations of an object of this character.

The observation at Mt. Hamilton Sept. 7 gives

$$\Delta\lambda = +4'' \quad , \quad \Delta\beta = +2''.$$

No others have yet been compared.

These elements give the following coordinate formulas for the equator of 1896.0:

$$
\begin{aligned}
x &= [0.422063]\ \sin(E + 72^\circ\ 23'\ 15'') - 1.210844\\
y &= [0.368362]\ \sin(E + 336\ 47\ 50) + 0.442303\\
z &= [9.732966]\ \sin(E + 352\ 13\ 23) + 0.035171
\end{aligned}
$$

and the following ephemeris for Greenwich midnight.

Date	α	δ	log Δ	Br.
	h m s	° ′		
Oct. 7.5	18 28 55	−12 15.8	0.0614	0.95
9.5	34 41	28.4	.0638	
11.5	40 32	40.0	.0663	
13.5	46 28	12 50.9	.0688	
15.5	52 30	13 0.9	.0714	0.94
17.5	18 58 37	10.0	.0740	
19.5	19 4 49	18.1	.0766	
21.5	11 6	25.3	.0793	
23.5	17 27	31.4	.0820	0.90
25.5	23 51	36.6	.0848	
27.5	30 20	40.7	.0877	
29.5	36 52	43.7	.0906	
31.5	19 43 26	−13 45.7	0.0935	0.85

The unit of brightness is that of Sept. 5.

Washington, 1896 *Oct.* 7.

OBSERVATIONS OF COMET 1894 IV,

MADE AT THE CHAMBERLIN OBSERVATORY, UNIVERSITY PARK, COLORADO,

By HERBERT A. HOWE.

1894-95 Univ. Park M.T.		*	No. Comp.	☄ − *		☄'s apparent		log *p*Δ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Nov. 29	8 18 50	1	10 , 10	−1 31.55	+1 37.7	23 44 13.67	−10 5 9.6	9.394	0.813
Dec. 15	7 10 53	2	10 , 10	+0 11.44	−2 23.4	23 29 6.10	− 4 36 15.3	9.194	0.784
17	7 13 16	3	1 , 1	0.00	0.0	23 34 31.32	− 3 55 51.1	9.218	0.779
	8 3 36	3	10 , 10	+0 5.33	+0 39.2	23 34 36.65	− 3 55 11.9	9.404	0.775
18	7 40 12	4	10 , 10	+0 1.70	−2 56.6	23 37 16.12	− 3 35 21.0	9.334	0.775
19	7 54 7	5	14 , 10	−2 33.41	+5 34.6	23 39 59.00	− 3 15 10.6	9.383	0.771
20	6 50 55	6	20 , 10	+0 3.23	−2 45.1	23 42 31.97	− 2 56 5.2	9.115	0.772
21	6 37 58	7	10 , 10	+0 0.70	+2 39.5	23 45 10.76	− 2 36 23.9	9.034	0.770
22	6 49 49	8	15 , 10	−0 26.50	−1 41.7	23 47 51.84	− 2 16 22.1	9.124	0.767
25	6 48 11	9	5	. . . .	−1 47.3	. . . .	− 1 17 34.0	. .	0.759
	7 7 33	9	2	+0 17.74	. . .	23 55 47.75	. . . .	9.238	. .
31	6 42 15	10	5	. . . .	+4 8.7	. . . .	+ 0 37 27.7	. .	0.742
	7 3 10	10	4	−0 4.22	. . .	0 11 19.77	. . . .	9.255	. .
Jan. 19	8 30±	11	1 . 1	0.00	0.0	0 58 38.01	+ 6 17 14.3	9.556	0.708

Mean Places, for beginning of year, of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	m s ′ ″
1	22 45 42.21	+3.01	−10 7 1.3	+14.0	Foll. Arg. G.C. 31007, 4 56.71 8 11.0 N
2	23 28 51.66	+3.00	− 4 34 9.3	+17.4	Foll. Arg. G.C. 31837, 2 48.89 5 46.8 N
3	23 34 28.32	+3.00	− 3 56 8.9	+17.8	Prec. Brussels 10616, 3 40.80 2 8.1 S
4	23 37 11.72	+3.00	− 3 32 42.3	+17.9	Foll. Lalande 46315.6, 3 49.71 0 1.7 N
5	23 42 29.40	+3.01	− 3 21 3.4	+18.2	Arg. G.C.32147 and Yarnall 10782
6	23 42 25.75	+2.99	− 2 53 38.3	+18.2	Foll. Rad. (1890) 6339, 3 25.92 9 3.3 N
7	23 45 7.07	+2.99	− 2 39 21.8	+18.4	Prec. A. G.C. 32259, 4 5.69 7 12.0 S
8	23 48 15.35	+2.99	− 2 14 58.9	+18.5	Prec. Brussels 10730, 4 50.68 1 30.6 N
9	23 55 27.01	+3.00	− 1 16 5.7	+19.0	Prec. A. G.C. 32426, 4 10.68 10 37.0 S
10	0 11 20.97	+3.02	+ 0 32 59.1	+19.9	Foll. Munich (1880) 87, 3 31.56 0 24.7 N
11	0 58 38.06	−0.05	+ 6 17 12.0	+ 2.3	Foll. Glasgow (1870) 259, 0 18.12 5 8.2 N

The observations given above were originally published in *A.J.*, 333, 334, 339 and 344. But the value then used for a revolution of the micrometer-screw was over 0″.3 in error. The observations have been, therefore, reduced anew, and notes about the appearance of the comet have been added. The magnifying power used on the 20-inch equatorial was 185 diameters.

NOTES.

Nov. 29. A nucleus was suspected at first, but the comet grew faint in haze.

Dec. 15. At first the comet was large and diffuse, compared with its former appearance; it was elongated at a position-angle of about 240°. There seemed to be occasionally a small bright point near the preceding end.

Dec. 17. The comet was faint in haze, but had a short tail and definite nuclear point. When it was transiting over the star, the light of the latter overpowered the faint nucleus, and caused it to disappear.

Dec. 18. The comet was faint in haze.

Dec. 19. The nucleus was plain, though faint; a diffuse, bushy tail was suspected at a position-angle of about 60°.

Dec. 20. The nucleus was visible only occasionally.

Dec. 21. The comet was very faint; the seeing was fine; the nucleus was visible.

Dec. 22. The comet was difficult to see.

Dec. 25. The sky was dull; the comet was obliterated before a complete set of observations could be taken.

Dec. 31. The comet was very faint and diffuse; it occasionally showed a nuclear condensation.

Jan. 19. The comet was at the limit of visibility; it vanished when it transited over the comparison-star. The estimated time of coincidence may be several minutes in error.

CORRECTED EPHEMERIS OF THE COMPONENT *C*, OF THE PERIODIC COMET 1889 V,

By S. C. CHANDLER.

Through an inexcusable blunder the time of perihelion passage, in *A.J.*, no. 385, was given as 1896 Nov. 3.9297, instead of 1896 Nov. 3.026. The corrected ephemeris is:

Gr. M.T.	App. α	App. δ	log Δ
1896	h m s	° ′	
Oct. 3.5	22 10 37	−16 52.8	0.0502
7.5	11 6	16 21.8	.0591
11.5	12 6	15 54.3	.0692
15.5	13 38	15 21.3	.0796
19.5	15 40	14 46.0	.0903
23.5	22 18 11	−14 8.6	0.1015
Oct. 27.5	22 21 11	−13 29.3	0.1129
31.5	22 24 35	−12 48.3	0.1245

The relative geocentric position of *C*, with reference to *A*, varies quite uniformly from 2ᵐ 34ˢ following and 16′.8 north on Oct. 3, to 2ᵐ 2ˢ following and 15′.0 north on Oct. 31.

From the magnitude of these differences it is manifest that the remarks about the identity of the fragment heretofore observed during the present appearance lose their force.

COMET *c* 1896 (1889 V).

FINDING EPHEMERIS BY CHARLES LANE POOR.

(Continued from No. 383.)

Gr. M.T.	App. α	App. δ	log Δ	Br.
	h m s	° ′ ″		
Oct. 15.5	22 11 17	−15 37 13	0.0822	1.6
17.5	12 18	19 39		
19.5	13 25	1 34	0.0930	1.5
21.5	14 38	−14 43 7		
23.5	15 59	24 3	0.1040	1.5
25.5	17 28	1 28		
27.5	19 3	−13 44 28	0.1154	1.4
29.5	20 43	21 6		
31.5	22 31	3 8	0.1269	1.3
Nov. 2.5	24 26	−12 41 55		
4.5	26 24	20 13	0.1386	1.2
6.5	22 28 30	−11 58 0		
Nov. 8.5	22 30 40	−11 35 28	0.1504	1.2
10.5	32 57	12 37		
12.5	35 17	−10 49 21	0.1622	1.1
14.5	37 43	25 43		
16.5	40 13	1 50	0.1740	1.1
18.5	42 48	− 9 37 30		
20.5	45 27	12 59	0.1857	1.0
22.5	48 8	− 8 48 7		
24.5	50 56	23 0	0.1974	1.0
26.5	53 46	− 7 57 30		
28.5	56 10	31 55	0.2090	0.9
30.5	22 59 38	− 7 6 4		

ELEMENTS AND EPHEMERIS OF COMET *d* 1896 (*GIACOBINI*),*

BY PROF. STIMSON J. BROWN.

U.S. NAVAL OBSERVATORY.

[Communicated by Prof. WM. HARKNESS, U.S.N., Astronomical Director.]

A comparison of my observations with the ephemeris of Prof. SEARES (*Science Observer Circular*, Sept. 12, 1896), showed a rapidly-increasing deviation, amounting Sept. 11 to −10ˢ in right-ascension and +2′ in declination. An ephemeris which I computed from the elements of HUSSEY and PERRINE was still more rapidly divergent.

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* From Supplement to No. 385.

The following elements were derived from the observations of the Lick Observatory Sept. 5, and my own Sept. 8 and 11. An attempt to use Olbers's method showed it in this case to be quite unserviceable, and recourse was had to Oppolzer's method. The orbit is so evidently elliptical that no parabolic orbit can be expected to represent the comet's position for a period longer than a few days. A comparison of the present ephemeris with those computed from observations of Sept. 5, 6 and 7, shows a deviation Sept. 29 of 11^{M} in right-ascension and 45′ in declination. The comet's position is probably still more to the west than shown in my ephemeris.

Washington, D.C., 1896 *Sept.* 29.

Elements.

T = 1896 October 21.537
ω = 145° 26′ 31″
☊ = 191 58 3
i = 11 14 59
log. q = 0.13368

For middle observation. $\Delta\beta = +0''.3$, $\Delta\lambda \cos\beta = -1'.9$.

Ephemeris.

Gr. Midnight.	α	δ
	h m s	° ′
Sept. 17.5	17 38 18	− 9 37.1
23.5	17 53 43	−10 33.9
29.5	18 10 48	−11 27.6
Oct. 5.5	18 29 28	−12 16.6
11.5	18 49 41	−12 59.5

OBSERVATIONS OF COMET *d* 1896 (*GIACOBINI*),*

MADE AT THE U.S. NAVAL OBSERVATORY,

By Prof. STIMSON J. BROWN.

[Communicated by Prof. Wm. Harkness, U.S.N., Astronomical Director.]

Greenwich M.T.	*	No. Comp.	☄ − *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
d			m s	′ ″	h m s	° ′ ″		
Sept. 8.5602	1	. .	−3 50.09	−3 39.66	17 18 36.54	−8 10 47.8	9.4172	0.7986
9.5770	2	. .	−0 34.45	+2 25.67	20 37.61	−8 20 35.9	9.4761	0.7947
10.5521	3	. .	−0 13.00	+4 18.68	22 36.17	−8 29 59.3	9.3866	0.8016
11.5453	4	. .	−0 20.84	+1 50.80	17 24 38.67	−8 39 33.8	9.3621	0.8038

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	17 22 23.60	+3.025	−8 6 59.6	−5.57	½ (Radcliffe 1890 + Greenw. 1880)
2	17 21 9.06	+3.000	−8 22 55.83	−5.54	From *1, $\Delta\alpha$ −1^{m} 14^{s}.54 ; $\Delta\delta$ −15′ 56″.22
3	17 22 34.67	+2.990	−8 34 12.2	−5.81	From *3*a*, $\Delta\alpha$ +2^{m} 24^{s}.20 ; $\Delta\delta$ + 0′ 30″.62
3*a*	17 20 10.47	+2.990	−8 34 42.8	−5.81	¼(2 Schj. + M. I + M. II)
4	17 24 56.51	+3.000	−8 41 19.0	−5.50	From *4*a*, $\Delta\alpha$ +0^{m} 15^{s}.44 ; $\Delta\delta$ +6′ 9″.6
4*a*	17 24 41.07	+3.000	−8 47 28.6	−5.50	½ (Weisse's Bessel + Munich I)

Magnifying power 200. The following corrections have been applied to reduce to a common epoch: Sept. 8, $\Delta\delta$ — 3″.0 for +7^{m}.8; Sept. 9, $\Delta\delta$ — 0″.2, for +0^{m}.5; Sept. 10, $\Delta\alpha$ — 0^{s}.19 for —2^{m}.2; Sept. 11, $\Delta\delta$ — 0″.1 for +0^{m}.3.

ELEMENTS AND EPHEMERIS OF COMET *d* 1896 (*GIACOBINI*),

By F. H. SEARES.

With the assistance of Mr. R. T. Crawford, I have recomputed the elements of the comet found by Giacobini. The observations used were made at the Lick Observatory by Professor Hussey on Sept. 5, 11 and 28 — two observations of the last date being combined into a single position for the computation.

The following parabolic elements have been obtained by variation of the ratio of the geocentric distances (M), the approximations being continued until two successive trials produced no change in this ratio.

The elements are

T = Oct. 18.91806 Greenw. M.T.

$$\left.\begin{aligned} i &= 12^\circ\ 20'\ 0''.0 \\ \Omega &= 186\ 15\ 44.0 \\ \omega &= 136\ 10\ 6.1 \end{aligned}\right\}\text{Mean Equinox of 1896.0}$$

q = 1.615267

Represention of the middle places, (O − C):

$\Delta\lambda \cos\beta = -5''.9$; $\Delta\beta = -20''.6$.

Professor Hussey writes me that the position of Sept. 11 was obtained by combining two incomplete observations, — the declination of the first being reduced to the term of the second. This may partially account for the relatively large residual in latitude.

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* From Supplement to No. 385.

The following ephemeris for Greenwich mean midnight has also been computed.

Gr. M.T.	α	δ	log ρ	Br.
Oct. 17.5	18h 58m 16s	−13 12.0		
18.5	19 1 19	16.3	0.1681	0.92
19.5	19 4 22	−13 20.4		
Oct. 20.5	19 7 27	−13 24.2		
21.5	10 32	27.8		
22.5	13 38	31.2	0.1745	0.89
23.5	16 45	34.3		
24.5	19 52	37.1		
25.5	23 0	39.7		
26.5	19 26 9	−13 42.0	0.1811	0.86

Students' Observatory, Univ. of Cal., 1896 Oct. 8.

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH EQUATORIAL AND FILAR MICROMETER AT GOODSELL OBSERVATORY, NORTHFIELD, MINN.,

BY H. C. WILSON.

1896 Northfield M.T.	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
			PERIODIC COMET *c* 1896 = 1889 V.					
Aug. 17 15h 8m 9s	1	12, 6	+0m 28.69s	−4′ 10.9″	22h 30m 5.32s	−19° 1′ 4.9″	9.426	0.874
Sept. 2 11 38 43	2	9, 8	−1 23.27	−1 48.9	22 19 19.42	−19 7 0.4	8.325	0.897
7 10 17 16	3	12, 6	+0 18.18	+0 46.3	22 16 6.60	−19 0 41.1	8.966	0.895
			COMET *d* 1896 (GIACOBINI.)					
Sept. 11 8 29 16	4	8, 4	+0 3.59	+7 16.2	17 21 47.78	− 8 40 17.1	9.417	0.845
			COMET *e* 1896 (SPERRA.)					
Sept. 28 10 29 19	5	6, 4	+0 56.42	−2 55.5	16 13 23.11	+48 9 29.0	9.790	0.710

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	22h 29m 32.39s	+4.24s	−18° 57′ 14.6″	+20.6″	Oe.-Arg. S., 17477
2	22 20 38.29	+4.40	−19 5 31.2	+19.7	Cincinnati Z.C. 3777
3	22 15 44.01	+4.41	−19 1 46.4	+19.0	Cincinnati Z.C. 3761
4	17 24 11.20	+3.00	− 8 47 27.8	− 5.5	Munich$_{(1)}$ 14102
5	16 12 25.81	+0.85	+18 12 23.9	+ 1.6	Oe.-Arg. N., Z. 4,63

NOTES.

Aug. 17. Comet faint and small, yet easily observed with the 16-inch telescope. It has a quite strong nuclear condensation.

Sept. 11. Giacobini comet very faint, round, about 1′ in diameter, with slight central condensation.

Sept. 28. Sperra comet exceedingly faint in moonlight, 1′ to 2′ in diameter, with very slight condensation. This observation should be given very little weight.

NOTICE.

Mr. R. G. AITKEN of the Lick Observatory requests that any unpublished observations of the Comet *b* 1896 (SWIFT) be sent him, as he desires to compute definitive elements for this comet, employing all observations which have been made.

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NOTICE.

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EPHEMERIS OF LONG-PERIOD VARIABLES FOR 1897,

BY S. C. CHANDLER.

The following ephemeris contains all stars of over four months period, for which elements are given in the Third Catalogue, except three (2213 *η Geminorum*, 7754 *W Cygni* and 8591 *V Cephei*) whose moderate range of variation requires observation in all stages to determine their phases. The star 2815 *U Geminorum* is included on account of its peculiarities and importance.

The form of the ephemeris is that which seems best adapted to enable observers to select with facility, for their working-lists, the objects most suitable to their means and situation. The stars whose maxima or minima occur in each calendar month are arranged in order of right ascension. The last two columns give the average magnitude at the phase, and its date, according to the elements of the Third Catalogue. The sign : indicates that the elements are noted in the catalogue as uncertain. In a large proportion of the minima a dash is placed in the date column. These are cases in which the column $M-m$ of the catalogue contains no data. Notwithstanding the lack of direct observation of the minimum-phase of these stars, I have thought it desirable to make a guess at the month in which they are likely to occur, as a means of assisting and inciting astronomers to the observation of these minima — this being the direction in which our knowledge of the variables is most defective. While the most effective work of this kind can be prosecuted only by telescopes of large aperture, it will be found that much can be done of great value with instruments of moderate size. Even if a star cannot be followed through its minimum, the mean of the times of its equality of brightness with a faint comparison-star, before and after disappearance, if the invisibility is not of long duration, will furnish an approximate determination of the epoch of minimum which will be very serviceable.

It may not be amiss to indicate the stars for which observations of either maxima or minima are most urgently needed. Especially in arrears are nos. 5903, 5928, 6624, 7234 and 7944; in a less degree, nos. 432, 715, 2857, 4492, 4826, 5430, 5504, 5593, 5617, 5795, 5856, 5889, 7139, 7444, 7779, 7907 and 8597.

MAXIMA, 1897.

		M	Jan.
110	*S* Tucanae	8.5	18 :
434	*S* Piscium	8.5	1
466	*U* Piscium	9.5	15
513	*R* Piscium	8	10
715	*S* Arietis	9.5	0
1577	*R* Tauri	8	12
1623	*T* Camelop.	7.5	16
1635	*R* Reticuli	7	22
2539	*R* Canis min.	7.5	10
2780	*T* Geminorum	8.5	19
2815	*U* Geminorum	9.3	1 :
3418	*R* Carinae	5	9
3425	*X* Hydrae	8.5	31
4557	*S* Ursae Maj.	7.5	15
4596	*U* Virginis	8	31
5494	*S* Librae	8	27
5593	*W* Librae	10	5
5776	*X* Scorpii	10	1
5830	*R* Scorpii	10	13

		M	Jan.
6050	*RS* Scorpii	7	1 :
6512	*T* Herculis	7.5	31
6894	*S* Lyrae	9	25 :
6921	*S* Sagittarii	9.5	14
7085	*RT* Cygni	7	28
7404	*R* Microsc.	8	2
7455	*U* Capricorni	10.5	6
7482	*U* Pavonis	9.5	29 :
7659	*T* Capricorni	9	28
8153	*R* Lacertae	9	29
8324	*V* Cassiopeae	7.5	16
8622	*W* Ceti	8.5	25
		M	Feb.
103	*T* Androm.	8	6
1582	*S* Tauri	9.5	17
1850	*S* Pictoris	8.5	2 :
2583	L_2 Puppis	3.5	17
3264	*W* Cancri	9.5	24 :

		M	Feb.
3825	*R* Ursae Maj.	7	6
4225	*X* Centauri	8	20 :
4816	*V* Virginis	8.5	27
5249	*V* Librae	9.5	10 :
5338	*U* Bootis	9.5	14
5617	*U* Librae	9	3
5795	*W* Scorpii	10.5	3
5903	*Y* Scorpii	10	15 :
5950	*W* Herculis	8	9
6207	*Z* Ophiuchi	8	26
6849	*R* Aquilae	6.5	18
7120	χ Cygni	5	23
7448	*W* Aquarii	8	17
8373	*S* Pegasi	7.5	2
		M	Mar.
22	*V* Sculptoris	9	16
294	*W* Cassiopeae	8.5	30 :
893	*U* Ceti	7	18

		M	Mar.
976	*T* Arietis	8	29
1944	*S* Orionis	9	23
2080	*R* Columbae	8	26 :
2100	*U* Orionis	7	18
2258	*V* Aurigae	9	27
2742	*S* Geminorum	8.5	26
2815	*U* Geminorum	9.3	29 :
3170	*S* Hydrae	8	24
3567	*V* Leonis	8.5	28
3637	*S* Carinae	6	9
4407	*R* Corvi	7	2
5037	*RR* Virginis	11	9
5070	*Z* Virginis	10	7
5157	*S* Bootis	8	23
5430	*T* Librae	9.5	19
5438	*Y* Librae	8.5	21 :
5504	*S* Coronae	7	13
5566	*RU* Librae	8.5	16 :
5931	*S* Ophiuchi	8.5	7

		M	
			Mar.
6044	*S* Herculis	6.5	7
7242	*S* Aquilae	9	12
7266	*RT* Sagittarii	7.5	18
7431	*S* Delphini	9	14
7560	*R* Vulpeculae	8	28
7999	*X* Aquarii	8.5	3
			April
782	*R* Arietis	8	28
906	*R* Trianguli	6.5	28
2445	*W* Monocerotis	9	14 :
4826	*R* Hydrae	4.5	20
5095	*R* Centauri	6	27
5174	*RS* Virginis	8	15
5191	*V* Bootis	7	12
5321	*S* Lupi	9.5	1 :
6132	*R* Ophiuchi	7.5	22
6923	*Z* Sagittarii	8.5	14
6943	*T* Sagittae	8.5	17 :
7077	*T* Pavonis	7.5	29
7139	*RR* Sagittarii	7.5	15
7260	*Z* Aquilae	9	12 :
7779	*S* Cephei	8.5	10
8068	*S* Lacertae	8	12
			May
62	*S* Sculptoris	6.5	11 :
401	*U* Sculptoris	8.5	15 :
845	*R* Ceti	8	5
1222	*R* Persei	8.5	8
1717	*V* Tauri	9	20
2528	*R* Geminorum	7	27
3991	*S* Leonis	9.5	17
4260	*W* Centauri	8.5	26 :
4511	*T* Ursae Maj.	7	29
4521	*R* Virginis	7	22
5511	*RS* Librae	8	18
5583	*X* Librae	9.5	9
5675	*V* Coronae	7.5	7
5831	*S* Scorpii	10	28
6449	*T* Draconis	8	15 :
6608	*RV* Sagittarii	8	14
7192	*Z* Cygni	8	7
7220	*S* Cygni	10	3
7401	*R* Microscopii	8	21
7444	*T* Delphini	9	11
7456	*RR* Cygni	8.5	21 :
7571	*V* Capricorni	9	6
7909	*S* Piscis Aust.	9	23
			June
1386	*T* Eridani	7	17
2625	*V* Geminorum	8.5	26
2815	*U* Geminorum	9.3	23 :
2976	*V* Cancri	7	15
			June
4847	*S* Virginis	6.5	8
4918	*R* Canum Ven.	6.5	22
5501	*S* Serpentis	8	10
5955	*R* Draconis	7.5	8
6682	*X* Ophiuchi	7	5
6905	*R* Sagittarii	7.5	20
7118	*X* Aquilae	8.5	6
7428	*V* Cygni	8	20
7577	*X* Capricorni	10	21
7907	*U* Aquarii	9.5	27 :
7944	*T* Pegasi	9	11
8040	*S* Gruis	7	14
8230	*S* Aquarii	8.5	24
			July
112	*R* Androm.	7	5
114	*S* Ceti	7.5	25
243	*U* Cassiopeae	8.5	11
466	*U* Piscium	9.5	7
1894	*T* Columbae	7.5	10
2583	L_2 Puppis	3.5	7
2587	*U* Puppis	8.5	27
3060	*U* Cancri	9.5	21
4315	*R* Comae	7.5	22
4377	*T* Virginis	8.5	25
4492	*Y* Virginis	8.5	25
4940	*W* Hydrae	6.5	27
5237	*R* Bootis	7	31
5593	*W* Librae	10	30
5776	*X* Scorpii	10	19
6062	*RR* Scorpii	7	6
6170	*RW* Scorpii	9.5	15 :
6512	*T* Herculis	7.5	14
6900	*W* Aquilae	7.5	10 :
7252	*W* Capricorni	10.5	18
7455	*U* Capricorni	10.5	28
7468	*T* Aquarii	7.5	3
7733	*Y* Capricorni	10.5	10
7813	*R* Gruis	8.5	20 :
8597	*V* Ceti	9	9
			Aug.
1582	*S* Tauri	9.5	24?
1771	*R* Leporis	6.5	10
2266	*V* Monocerotis	6.5	28
2478	*R* Lyncis	8	5
2691	*T* Canis min.	9.5	5
3477	*R* Leonis min.	7	7
3637	*S* Carinae	6	1
4557	*S* Ursae Maj.	7.5	25
4596	*U* Virginis	8	26
5338	*U* Bootis	9.5	10
5494	*S* Librae	8	7
5704	*RR* Librae	8.5	5
5830	*R* Scorpii	10	25
			Aug.
5887	*V* Ophiuchi	7	3
6903	*T* Sagittarii	8	15
7085	*RT* Cygni	7	8
7242	*S* Aquilae	9	5
7260	*Z* Aquilae	9	20 :
7450	*V* Aquarii	8	23
7560	*R* Vulpeculae	8	13
7994	*S* Pisc. aus.	8.5	1 :
			Sept.
110	*S* Tucanae	8.5	8 :
1805	*V* Orionis	8.5	4 :
1981	*S* Camelop.	8.5	19
2013	*U* Aurigae	8.5	24
2080	*R* Columbae	8	6 :
2530	*V* Canis min.	10	10
2684	*S* Canis min.	7.5	29
2815	*U* Geminorum	9.3	17 :
3128	*R* Pyxidis	8	22 :
3184	*T* Hydrae	7.5	11
5190	*R* Camelop.	8	12
5617	*U* Librae	9	17
5644	*Z* Librae	11	21
5677	*R* Serpentis	6.5	21
5761	*Z* Scorpii	9	4
5795	*W* Scorpii	10.5	13
6921	*S* Sagittarii	9.5	1
6943	*T* Sagittae	8.5	29
7155	*RR* Aquilae	8.5	14 :
7234	*R* Capricorni	9.5	23 :
7261	*R* Delphini	8.5	12
8290	*R* Pegasi	7.5	22
8324	*V* Cassiopeae	7.5	2
8512	*R* Aquarii	7	19
			Oct.
103	*T* Androm.	8	29
678	*U* Persei	7.5	17 :
715	*S* Arietis	9.5	19
782	*R* Arietis	8	31
815	*R* Ceti	8	19
1018	*R* Horologii	6	15 :
1113	*U* Arietis	8	22
1803	*T* Leporis	8	25 :
3493	*R* Leonis	6	8
4521	*R* Virginis	7	14
5037	*RR* Virginis	11	12
5095	*R* Centauri	6	5
5583	*X* Librae	9.5	20
5770	*R* Herculis	8.5	8
5889	*U* Herculis	7	22
5928	*T* Ophiuchi	10	27 :
5931	*S* Ophiuchi	8.5	26
6871	*V* Lyrae	9	10 :
7404	*R* Microscopii	8	7
			Nov.
7659	*T* Capricorni	9	24
62	*S* Sculptoris	6.5	10 :
806	*o* Ceti	3.5	9
893	*U* Ceti	7	9
1717	*V* Tauri	9	6
1761	*R* Orionis	9	17
2583	L_2 Puppis	3.5	24
2780	*T* Geminorum	8.5	3
3418	*R* Carinae	5	11
3425	*X* Hydrae	8.5	23
3994	*S* Leonis	9.5	26
4816	*V* Virginis	8.5	5
5430	*T* Librae	9.5	12
5601	*S* Ursae min.	7.5	10
5831	*S* Scorpii	10	21
5856	*W* Ophiuchi	9	6
5950	*W* Herculis	8	21
6050	*RS* Scorpii	7	4 :
6331	*RU* Scorpii	9.5	30 :
6624	*T* Serpentis	10	28
7456	*RR* Cygni	8.5	2 :
7482	*U* Pavonis	9.5	15 :
7783	*RU* Cygni	7.5	27
8153	*R* Lacertae	9	24
			Dec.
419	*U* Androm.	9	25 :
466	*U* Piscium	9.5	27
513	*R* Piscium	8	18
1222	*R* Persei	8.5	3
1577	*R* Tauri	8	3
2445	*W* Monocerotis	9	33 :
2539	*R* Canis min.	7.5	13
2815	*U* Geminorum	9.3	13 :
2946	*R* Cancri	7	9
3170	*S* Hydrae	8	6
3567	*V* Leonis	8.5	27
3637	*S* Carinae	6	31
3825	*R* Ursae Maj.	7	8
4225	*X* Centauri	8	31 :
5157	*S* Bootis	8	7
5194	*V* Bootis	7	24
5438	*Y* Librae	8.5	18 :
5511	*RS* Librae	8	25
6512	*T* Herculis	7.5	25
7045	*R* Cygni	7	1
7077	*T* Pavonis	7.5	28
7242	*S* Aquilae	9	30
7260	*Z* Aquilae	9	28 :
7431	*S* Delphini	9	17
7560	*R* Vulpeculae	8	29
7609	*T* Cephei	6	1
8068	*S* Lacertae	8	1
8373	*S* Pegasi	7.5	16
8600	*R* Cassiopeae	6	30

MINIMA, 1897.

		M	Jan.
112	*R* Androm.	<13	16 :
401	*U* Sculpt.	<12	—
782	*R* Arietis	12	26
1771	*R* Leporis	8.5	10
2528	*R* Geminor.	<13	26
3994	*S* Leonis	<13	12 :
4847	*S* Virginis	12.5	1 :
4940	*W* Hydrae	8	—
4918	*R* Can. Ven.	11.5	—
5194	*V* Bootis	9.5	5
5511	*RS* Librae	13	—
6170	*RW* Scorpii	14	—

		M	Jan.
6682	*X* Ophiuchi	9	—
6905	*R* Sagittar.	12.5	26
7077	*T* Pavonis	12	—
7192	*Z* Cygni	11.5	2 :
7560	*R* Vulpeculae	13	25
7909	*S* Pisc. Aust.	<11	—

		M	Feb.
845	*R* Ceti	13	24
1222	*R* Persei	13	1
1386	*T* Eridani	11	—
1717	*V* Tauri	<13	27
2625	*V* Geminor.	13	14
2976	*V* Cancri	<12	25
3477	*R* Leo. min.	13	18
4315	*R* Comae	<13	—
4377	*T* Virginis	12	—
4511	*T* Virginis	12.5	10
5095	*R* Centauri	9	26 :
5583	*X* Librae	14	18
5831	*S* Scorpii	<13	—
5887	*V* Ophiuchi	10	8 :
5955	*R* Draconis	12.5	16
6903	*T* Sagittarii	11	—
6943	*T* Sagittae	9.5	26 :
7155	*RR* Aquilae	<12	—
7260	*Z* Aquilae	11	—
7456	*RR* Cygni	9.5	—
7571	*V* Capric.	14	—
7577	*X* Capric.	<16	24 :
7813	*R* Gruis	<12	—
7907	*U* Aquarii	14	—
8230	*S* Aquarii	<12	—

		M	Mar.
114	*S* Ceti	12	2
1894	*T* Columbae	11	—
2013	*U* Aurigae	12	—
2266	*V* Monocer.	11	—
2478	*R* Lyncis	<13	15
2530	*V* Can. min.	<13	—
2691	*T* Can. min.	<13	—
2857	*U* Puppis	<14	—
3060	*U* Cancri	<14	—
4521	*R* Virginis	10.5	15
5704	*RR* Librae	14	—
5761	*Z* Scorpii	12	—
6062	*RR* Scorpii	9.5	3 :
7404	*R* Microsc.	12	18
7733	*Y* Capric.	14	—
7994	*R* Pisc. Aust.	<11	—
8512	*R* Aquarii	11	11
8597	*V* Ceti	14	—

		M	Apr.
243	*U* Cassiop.	<15	2
466	*U* Piscium	15	15
1018	*R* Horologii	10	—
1761	*R* Orionis	12	17 :
1981	*S* Camelop.	11	3
2583	L_2 Puppis	6	29
2684	*S* Can. min.	11	18

		M	Apr.
3128	*R* Pyxidis	<11	—
5237	*R* Bootis	12	20
5494	*S* Librae	<13	—
5677	*R* Serpentis	13	23
5776	*X* Scorpii	<13	—
5795	*W* Scorpii	<11	20 :
6512	*T* Herculis	11	27
6871	*V* Lyrae	<12	—
7234	*R* Capric.	<13	—
7252	*W* Capric.	<14	22 :
7261	*R* Delphini	12	15 :
7450	*V* Aquarii	9.5	—
7455	*U* Capric.	<13	—
7468	*T* Aquarii	12.5	7
8290	*R* Pegasi	<13	3 :

		M	May
107	*T* Cassiop.	11.5	20
110	*S* Tucanae	<11	—
432	*S* Cassiop.	<13	9 :
678	*U* Persei	11.5	2 :
715	*S* Arietis	14	7 :
1113	*U* Arietis	<11	—
1803	*T* Leporis	11	—
1805	*V* Orionis	<13	7 :
3184	*T* Hydrae	<13	—
3493	*R* Leonis	10	17
3637	*S* Carinae	9	10
4492	*Y* Virginis	12	1 :
4511	*S* Urs. Maj.	11	4
4596	*U* Virginis	12.5	30
5190	*R* Camelop.	12.5	15 :
5338	*U* Bootis	12.5	7
5593	*W* Librae	<14	—
5617	*U* Librae	<14	—
5644	*Z* Librae	<13	—
5770	*R* Herculis	<13	—
5830	*R* Scorpii	<13	—
5889	*U* Herculis	12	8
6331	*RU* Scorpii	12.5	—
6921	*S* Sagittarii	14.5	14 :
7085	*RT* Cygni	10.5	12
7242	*S* Aquilae	11	25
7609	*T* Cephei	9.5	15
7659	*T* Capricorni	13.5	28
7783	*RU* Cygni	9	—
8324	*V* Cassiopeae	12	20

		M	June
1582	*S* Tauri	13	15?
1635	*R* Reticuli	<13	—
1855	*R* Aurigae	12.5	24
2080	*R* Columbae	11.5	—
2780	*T* Geminor.	<13	—
3418	*R* Carinae	9.5	28
5037	*RR* Virginis	<14	—
5601	*S* Ursae min.	11.5	—
5856	*W* Ophiuchi	<13	—
6050	*RS* Scorpii	11.5	—
6624	*T* Serpentis	<13	—
7260	*Z* Aquilae	11	—

		M	June
7299	*U* Cygni	10.5	14
7182	*U* Pavonis	<12	—
7560	*R* Vulpeculae	13	12
8600	*R* Cassiopeae	10	25

		M	July
103	*T* Androm.	13	—
434	*S* Piscium	<14	25
513	*R* Piscium	<13	22
659	*X* Cassiopeae	12	—
782	*R* Arietis	12	31
806	o Ceti	9	20
893	*U* Ceti	12	10 :
1577	*R* Tauri	13	16 :
1623	*T* Camelop.	<12	30 :
3170	*S* Hydrae	<12	—
3425	*X* Hydrae	12	—
3994	*S* Leonis	<13	24 :
4816	*V* Virginis	<13	—
5430	*T* Librae	<14	30
5931	*S* Ophiuchi	<13	—
5950	*W* Herculis	13	19
7045	*R* Cygni	<14	4
7571	*V* Capricorni	14	—
7590	*Z* Capricorni	11.5	—
8153	*R* Lacertae	<13	—
8373	*S* Pegasi	13	26 :
8622	*W* Ceti	12	—

		M	Aug.
22	*V* Sculpt.	<12	—
62	*S* Sculptoris	10	—
845	*R* Ceti	13	10
1222	*R* Persei	13	29
1717	*V* Tauri	<13	16
1850	*S* Pictoris	<13	—
2445	*W* Monocer.	<10	—
2539	*R* Canis min.	10	5 :
2735	*U* Canis min.	12.5	8
2946	*R* Cancri	<11	6 :
3186	*T* Cancri	10	29
3567	*V* Leonis	<13	—
3825	*R* Ursae Maj.	12.5	23
4225	*X* Centauri	12	13 :
4407	*R* Corvi	<11	—
4521	*R* Virginis	10.5	6
5070	*Z* Virginis	<14	—
5095	*R* Centauri	9	6 :
5157	*S* Bootis	12.5	3
5249	*V* Librae	12	—
5438	*Y* Librae	12	—
5583	*X* Librae	14	1
5831	*S* Scorpii	<13	—
5903	*Y* Scorpii	14	—
6044	*S* Herculis	12	14 :
6207	*Z* Ophiuchi	12	28 :
6849	*R* Aquilae	11	15
6894	*S* Lyrae	12	—
6943	*T* Sagittae	9.5	10 :
7077	*T* Pavonis	12	—
7266	*RT* Sagittarii	<11	—
7404	*R* Microsc.	12	4

		M	Aug.
7431	*S* Delphini	11	21
7456	*RR* Cygni	9.5	—
7458	*V* Delphini	12	—
7999	*X* Aquarii	13	—
8068	*S* Lacertae	<12	10

		M	Sept.
906	*R* Trianguli	11.5	24
2583	L_2 Puppis	6	16
2742	*S* Geminor.	<13	9 :
3264	*W* Cancri	<13	—
5194	*V* Bootis	9.5	18
5511	*RS* Librae	13	—
5566	*RU* Librae	<12	—
5704	*RR* Librae	11	—
6132	*R* Ophiuchi	<12	—
7192	*Z* Cygni	11.5	24 :
7448	*W* Aquarii	9.5	6 :
7577	*X* Capric.	<16	27 :

		M	Oct.
294	*W* Cassiopeae	11.5	8 :
466	*U* Piscium	15	5
976	*T* Arietis	9.5	1
1894	*T* Columbae	11	—
1944	*S* Orionis	12	28
2258	*V* Aurigae	<11	1 :
3637	*S* Carinae	9	6
4511	*T* Ursae Maj.	12.5	23
5174	*RS* Virginis	12	—
5321	*S* Lupi	<12	—
5338	*U* Bootis	12.5	31
5776	*X* Scorpii	<13	—
5955	*R* Draconis	12.5	19
6512	*T* Herculis	11	8
6608	*RV* Sagittarii	12	—
6905	*R* Sagittarii	12.5	25
7120	χ Cygni	13.5	15 :
7139	*RR* Sagittarii	<12.5	30 :
7220	*S* Cygni	<14	20 :
7242	*S* Aquilae	11	19
7260	*Z* Aquilae	11	—
7468	*T* Aquarii	12.5	28
7733	*Y* Capric.	14	—
7907	*U* Aquarii	14	—
7909	*S* Pisc. Aust.	<11	—

		M	Nov.
1386	*T* Eridani	11	—
2080	*R* Columbae	11.5	—
2100	*U* Orionis	<12	3 :
2625	*V* Geminor.	13	17
2976	*V* Cancri	<12	25
5494	*S* Librae	<13	—
5504	*S* Coronae	12	12
5593	*W* Librae	<14	—
5675	*V* Coronae	11	9
5795	*W* Scorpii	<14	29
6923	*Z* Sagittarii	<12	—
7085	*RT* Cygni	10.5	19
7252	*W* Capric.	<14	15 :
7444	*T* Delphini	<13	—

		M	Nov.			M	Dec.			M	Dec.			M	Dec.
7455	*U* Capric.	<13	—	1582	*S* Tauri	13	20 :	5237	*R* Bootis	12	1	7104	*R* Microsc.	12	20
7779	*S* Cephei	12	23	3060	*U* Cancri	<14	—	5501	*S* Serpentis	12.5	—	7428	*U* Cygni	13.5	35
8230	*S* Aquarii	<12	—	4260	*W* Centauri	13	—	5830	*R* Scorpii	<13	—	7450	*U* Aquarii	9.5	—
8597	*U* Ceti	14	—	4492	*Y* Virginis	12	6 :	5887	*U* Ophiuchi	10	7 :	7914	*T* Pegasi	<13	—
				4557	*S* Urs. Maj.	11	11	6449	*T* Draconis	11	20 :	7994	*R* Pisc.aus.	<11	—
		M	Dec.	4596	*U* Virginis	12.5	23	6682	*X* Ophiuchi	9	—	8040	*S* Gruis	12	—
243	*U* Cassiop.	<15	34	4826	*R* Hydrae	9.5	6	6921	*S* Sagittarii	14.5	31	8324	*V* Cassiopeae	12	35 :
419	*U* Androm.	<13	—	4948	*R* Can. Ven.	11.5	—	7118	*X* Aquilae	<12	—				

The foregoing ephemeris conforms strictly to the elements of the Catalogue, with the single exception of 6449 *T Draconis*, for which I have used, instead, the period 435^d and $M-m = 216^d$:.

SHORT FORMULAS FOR GAUSS'S METHOD OF COMPUTATION OF AN ORBIT FROM THREE COMPLETE OBSERVATIONS,

By Rev. G. M. SEARLE.

The following formulas seem to me to give a short and convenient application of the method of Gauss, and have proved very satisfactory during the past few years, when I have had occasion to use them. I venture, also, to think, that sufficiently accurate results are obtained by them with as little labor — at any rate in the case of cometic orbits — as by those of Oppolzer, since the values of the two unknown quantities, x and y, which are involved, are already known in the computation of such orbits with considerable accuracy from the previous parabolic orbits which have been obtained; and especially since the quantities η and η'' can, usually in the orbits of periodic comets, be computed, for the intervals of time sufficient for a first determination, nearly enough by the simple parabolic expressions for them.

In the first place, we compute, once for all, the following quantities, in which $\lambda, \lambda', \lambda'', \beta, \beta', \beta''$ are the geocentric longitudes and latitudes of the object; L, L', L'', R, R', R'', the longitudes of the sun and radii vectores of the earth; t, t', t'', the times of the observations.

$$m = \sin(\lambda-L)\cot\beta \qquad \theta' = k(t''-t)$$
$$m'' = \sin(\lambda''-L'')\cot\beta'' \qquad \theta'' = k(t'-t)$$
$$N = R'R''\sin(L''-L') \qquad (1) = \sin(\lambda-L'') - m''\tan\beta$$
$$N' = RR''\sin(L''-L) \qquad (2) = \sin(\lambda'-L'') - m''\tan\beta'$$
$$N'' = RR'\sin(L'-L) \qquad (3) = \sin(\lambda'-L) - m\tan\beta'$$
$$\theta = k(t''-t') \qquad (4) = \sin(\lambda''-L) - m\tan\beta''$$

$$a = -(4)R\tan\beta \quad ; \quad a'' = (1)R''\tan\beta''$$

$$b = \frac{(2)}{(1)} \quad ; \quad b'' = \frac{(3)}{(4)}$$

$$c = N'\frac{\tan\beta''}{a''} \quad ; \quad c'' = N'\frac{\tan\beta}{a}$$

$$\frac{1}{e} = \tan\beta\sin(\lambda''-\lambda')+\tan\beta''\sin(\lambda'-\lambda)-\tan\beta'\sin(\lambda''-\lambda)$$

to which the value for the same quantity

$$\frac{N'}{cc''}\left[b\tan\beta+b''\tan\beta''-\tan\beta'\right]$$

may be added as a check.

$$\cos\psi' = \cos\beta'\cos(\lambda'-L') \; ; \; \cos\psi'' = \cos\beta''\cos(\lambda''-L'')$$

$$y = \frac{e}{R'}\sec\beta'\sec\psi' \; ; \; h = (a-a'')\frac{\theta''}{\theta'}$$

$$l = \left[a\frac{\theta}{\theta'}+a''\frac{\theta''}{\theta'}\right]e\sec\beta'(R'\sin\psi')^{-4}$$

$$x_0 = a\left(\frac{N}{N'}-\frac{\theta}{\theta'}\right)+a''\left(\frac{N''}{N'}-\frac{\theta''}{\theta'}\right)$$

With these we proceed at once to the formation of our trial equation. We denote by n, n', n'' the quantities corresponding in the unknown orbit to N, N', N'' in that of the earth, n for example being $r'r''\sin(v''-v')$; η the $\frac{\text{sector}}{\text{triangle}}$ between the second and third observations, η'' that between the first and second; $f = \frac{1}{2}(v''-v')$ &c.

We have then approximate values of

$$x = x_0 + h\frac{n}{n'}\left(\frac{\eta}{\eta''}-1\right)$$

$$y = \frac{\theta\theta''}{2}\cdot\frac{\sec f\sec f'\sec f''}{\eta\eta''}\cdot\frac{r'^2}{rr''}$$

Computing $\tan z_0 = \dfrac{\tan\psi'}{1+yx}$, we have for the trial equation $\sin(z'+z_0) = ly\sin z_0 \, . \, \sin^4 z'$.

We may evidently always take z_0 less than 180°.

By means of z' we compute

$$r' = \frac{R'\sin\psi'}{\sin z'} \;,\; \rho' = \frac{R'\cos\beta'\sin(z'+\psi')}{\sin z'}$$

$$\frac{n'}{n} = \frac{1+\frac{n''}{n}}{1+yr'^{-3}} \; ; \; \rho = \frac{n'}{n}b\rho' + c\left[\frac{n'}{n}\frac{N}{N'}-1\right]$$

From ρ we have
$$r\cos b\sin(l-\lambda) = R\sin(\lambda-L)$$
$$r\cos b\cos(l-\lambda) = \rho - R\cos(\lambda-L)$$
$$r\sin b = \rho\tan\beta$$

Similarly from ρ' obtain r' (which should agree with its value already found) l' and b'; l, l', b, b' are the heliocentric longitudes and latitudes of the comet. We have, next,

$$\tan\gamma = \frac{\sqrt{\cos b\cos b'}\sin\frac{1}{2}(l'-l)}{\sin\frac{1}{2}(b'-b)}$$

$$\sin f'' = \sin\tfrac{1}{2}(b'-b)\sec\gamma = \sqrt{\cos b\cos b'}\sin\tfrac{1}{2}(l'-l)\operatorname{cosec}\gamma$$

$$\tan\epsilon = \frac{n}{n'}\cdot\frac{r}{r'} \qquad \tan(f''+2f') = \tan f''\tan(\epsilon+45^\circ)$$

$$r'' = \frac{n}{n''}\cdot r\,\frac{\sin 2f''}{\sin 2f} = \frac{n}{n''}\cdot\frac{n'}{n}\,r'\,\frac{\sin 2f''}{\sin 2f'}$$

η and η'' may now be obtained by GAUSS's formulas, or as previously remarked, usually with sufficient accuracy by the parabolic formulas

$$\eta^2(\eta-1) = \frac{\frac{1}{6}\theta^2}{(r'r'')^{3/2}\cos^3 f} \qquad \eta''^2(\eta''-1) = \frac{\frac{1}{6}\theta''^2}{(rr')^{3/2}\cos^3 f''}$$

With the values of $\frac{n}{n'}$, η, η'', r, r', r'', f, f', f'', the values of x and y can now be recomputed for a new hypothesis, in which we use for $\frac{n''}{n}$ the value $\frac{\eta}{\eta''}\cdot\frac{\theta''}{\theta}$.

When it seems unnecessary to carry the approximation further, we compute

$$\sin z'' = \frac{R''\sin\psi''}{r''}$$

$$\rho'' = \frac{R''\cos\beta''\sin(z''+\psi'')}{\sin z''} = \frac{n'}{n''}\,b''\rho' + c''\left[\frac{n'}{n''}\cdot\frac{N''}{N'} - 1\right]$$

From ρ and ρ'' we obtain l, l'', b, b'', by the formulas already given; from them f', as f'' was obtained before. Or, as we have now to compute ☊ and i, we may use the formulas

$$\tan[\tfrac{1}{2}(l''+l)-\Omega] = \frac{\sin(b''+b)}{\sin(b''-b)}\tan\tfrac{1}{2}(l''-l)$$

$$\tan i = \frac{\tan b}{\sin(l-\Omega)} = \frac{\tan b''}{\sin(l''-\Omega)}$$

$$\left.\begin{aligned}\tan u &= \tan(\lambda-\Omega)\sec i\\ \tan u'' &= \tan(\lambda''-\Omega)\sec i\end{aligned}\right\} \qquad 2f' = u''-u$$

From r, r'', f', θ', we obtain the elements of the orbit in its plane. $\omega = \pi - \Omega$ of course is equal to $u - v$ or $u'' - v''$.

The fundamental equation,

$$\frac{\rho'}{e} = a\left(\frac{n}{n'}-\frac{N}{N'}\right) + a''\left(\frac{n''}{n'}-\frac{N''}{N'}\right) = \frac{a\theta+a''\theta''}{\theta'}\left[\frac{n+n''}{n'}-1\right]$$
$$+(a-a'')\left[\frac{\theta''}{\theta'}\frac{n}{n'}-\frac{\theta}{\theta'}\frac{n''}{n'}\right]+\frac{a\theta+a''\theta''}{\theta'}-a\frac{N}{N'}-a''\frac{N''}{N'}$$

from which the trial equation is obtained, is deduced from the equation

$$\begin{aligned}\frac{\rho'}{e} = {} & R\,\frac{n}{n'}[\tan\beta''\sin(\lambda-L)-\tan\beta\sin(\lambda''-L)]\\ & + R'[\tan\beta\sin(\lambda''-L')-\tan\beta''\sin(\lambda-L')]\\ & + R''\frac{n''}{n'}[\tan\beta''\sin(\lambda-L'')-\tan\beta\sin(\lambda''-L'')]\end{aligned}$$

by putting $R'[\tan\beta\sin(\lambda''-L')-\tan\beta''\sin(\lambda-L')]$ in the form

$$\begin{aligned}& -R\,\frac{N}{N'}[\tan\beta''\sin(\lambda-L)-\tan\beta\sin(\lambda''-L)]\\ & -R''\frac{N''}{N'}[\tan\beta''\sin(\lambda-L'')-\tan\beta\sin(\lambda''-L'')]\end{aligned}$$

which form will be verified by putting in it for N, N', N'', their values in terms of R, R', R'', L, L', L''.

OBSERVATIONS OF (33) *POLYHYMNIA*,

By Prof. STIMSON J. BROWN,

U.S. NAVAL OBSERVATORY.

[Communicated by Prof. Wm. Harkness, U.S.N., Astronomical Director.]

1896 Washington M.T.	*	No. Comp.	Planet — * Δα	Planet — * Δδ	Planet's apparent α	Planet's apparent δ	log p for α	log p for δ
			m s	′ ″	h m s	° ′ ″		
(1) April 6 12h 23m.4	1	5 , 3	+0 11.113	−2 4.98	12 2 50.86	−0 7 13.7	8.7824	0.3081
(2) 7 10 34.5	2	6 , 6	+0 18.660	−0 8.24	12 2 13.13	−0 3 26.8	*n*8.7993	0.3071
(3) 8 11 36.8	2	6 , 4	−0 25.62	+4 16.64	12 1 28.89	+0 0 58.1	*n*8.2367	0.3074
(4) 13 10 53.8	3	18 , 4	−1 26.50	+0 19.3	11 58 5.06	+0 21 16.5	8.2791	0.3032

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	12 2 37.32	+2.49	−0 4 54.45	−16.29	Comp. with no. 2; +45s.27, −1′ 50″.15
2	12 1 52.05	+2.48	−0 3 4.30	−16.26	$\frac{1}{5}$ (2 Yarnall + 2 Munich + Weisse's Bessel)
3	11 59 29.09	+2.45	+0 21 11.1	−15.90	Bonn VI., 2888

(1) Correction of α for parallax $+0^s.06$; for reduction to epoch of δ $-0^s.126$; correction of δ for parallax $+2''.03$.
(2) Correction for parallax $-0^s.06$, $+2''.00$; (3) Correction for parallax $-0^s.02$, $+2''.03$; (4) Correction for parallax $+0^s.02$, $+2''.00$.
The first three observations were made with the micrometer in both right-ascension and declination; each is given the same weight.

The comparison of the positions with the ephemeris of the Berlin *Jahrbuch* gave as follows: O − C

	Δα (s)	Δδ (″)		Δα (s)	Δδ (″)
No. 1.	+0.06	+0.7	No. 3.	−0.07	+1.0
No. 2.	−0.03	+1.1	No. 4.	0.00	−1.1

NOTE ON DIFFERENTIAL REFRACTION OF PHOTOGRAPHIC MEASURES.

(Reply to Mr. Dyson's Note in *A. J.*, No. 373.)

By HAROLD JACOBY.

In the above number of the *Journal*, Mr. Dyson, writing with the approval of Prof. Turner, claims that I have misunderstood and wrongly applied Prof. Turner's formulas. Mr. Dyson states that Prof. Turner's formulas are

$$(1)\qquad \begin{cases} \Delta\xi = -k'\{x-\xi(1+x^2)-\eta xy\} \\ \Delta\eta = -k'\{y-\xi xy-\eta(1+y^2)\} \end{cases}$$

whereas I took as Prof. Turner's formulas

$$(2)\qquad \begin{cases} \Delta\xi = k'\{(1+x^2)\xi+xy\eta\} \\ \Delta\eta = k'\{xy\xi+(1+y^2)\eta\} \end{cases}$$

It becomes, therefore, a simple question of fact as to what Prof. Turner's formulas really were. I must insist that except for differences of notation they were exactly as I have given them. Any astronomer who will examine the *Monthly Notices* for 1893 November, page 14, can satisfy himself that such is the ease. Moreover, Prof. Turner has published the formulas (2) again in the *Bulletin du Comité Permanent*, Vol. 2, p. 350. The formulas (1) are not there given. It is difficult to see why he should have misled his colleagues of the Committee by advising them to use the formulas (2), if the formulas he wished them to use were what Mr. Dyson now claims them to have been.

It is true that one of the formulas (1) appears as an intermediate step in the deduction of the formulas (2) in the *Monthly Notices* for 1893 November. But the final formulas are given in the form I have used, and they are stated to be the final formulas in unmistakable terms. This receives complete confirmation from the article referred to in the *Bulletin du Comité Permanent*.

It is, however, of no great interest whether the formulas which I took to be Prof. Turner's are correct. It is more important to consider the ones now given by Mr. Dyson. These would appear to give correct results, but they will be inconvenient on account of the great magnitude of the refraction corrections they involve. Thus in the example considered by Mr. Dyson, the correction of ξ amounts to more than twenty-four seconds of arc. I imagine that this is the largest differential refraction ever computed at a moderate zenith distance. In fact, most astronomers would refuse to admit Prof. Turner's right to call his result a *differential* refraction. This term has a settled meaning, namely, to define the difference between the refractions at two points of the sky very near each other. Prof. Turner's formula does not appear to me to come under this definition.

I must object to Mr. Dyson's statement on the top of the second column of p. 102 in No. 373 of the Journal. He says that I have given two contradictory statements in Nos. 350 and 354 of the *Journal*. I am unable to find these contradictory statements in any of my articles, nor have I published any article at all in No. 354 of the *Journal*.

The discussion with Mr. Dyson has, however, brought out one point with regard to my formulas which is of importance. As I pointed out in No. 366 of the *Journal*, it is proper to employ the *apparent* polar distance of the center of the plate when transforming into right-ascension and declination rectangular coordinates corrected for refraction with my formulas. While it is true that the actual angular distance between the pole of the heavens and the point on the sky corresponding to the center of the plate will be what is usually called the apparent polar distance of the center, yet when transformation tables are to be employed it will be better to base them on the true polar distance of the center, so that all the plates of the same declination may be reduced with the same tables. To make this possible, a small correction will be required by the tables; but this can just as well be applied to the refraction formulas, and an extra correction avoided.

In the notation used by me in my original article in No. 350 of the *Journal*, this correction is at once seen to be

$$+kG\tan\delta\sin 1''$$

to be applied to the quantity

$$M_x$$

After this correction has been applied, my refraction formulas become (3)

$$\begin{aligned} \sin n\sin N &= \cos q\cos(\theta-\alpha) \\ \sin n\cos N &= \sin q \\ G &= \cot(\delta+N) \\ H &= \tan(\theta-\alpha)\sin N\operatorname{cosec}(\delta+N) \\ M_x &= k(1+H^2)\sin 1'' \\ N_x &= \tfrac{1}{15}k(GH\sec\delta-H\tan\delta\sec\delta)\sin 1'' \\ M_y &= 15k(GH\cos\delta+H\sin\delta)\sin 1'' \\ N_y &= k(1+G^2)\sin 1'' \\ \text{Refr.corr. for } X\sec\delta &= M_x X\sec\delta+N_x Y \\ \text{Refr.corr. for } Y &= M_y X\sec\delta+N_y Y \end{aligned}$$

When these formulas are used the true declination of the center of the plate is to be employed in the further transformations of the rectangular coordinates into right-ascension and declination. These formulas are equivalent to those given by Mr. Dyson in No. 373 of the *Journal*, where they are numbered (11). They are also in accord with the corresponding formulas published very recently by M. Baillaud in the *Bulletin du Comité Permanent*, and are stated by him to be practically in accord with the refractions applied by M. Henry at Paris.

It is interesting to note that these formulas are practically equivalent to Prof. Turner's original formulas (2), such as I took them to be, whenever the constants for the reduction of the plate are derived from the measured coordinates of known stars on the plate. For the formulas (2) differ from (3) only by the terms

$$-kx \cot P\eta \text{ for } \xi \quad \text{and} \quad +kx \cot P\xi \text{ for } \eta.$$

It follows that the neglect of these terms simply has the effect of changing the orientation constant, which is a matter of no consequence when this constant is determined from the measured coordinates of known stars on the plate. Mr. Dyson might therefore have defended Prof. Turner's original formulas as they were printed by him in the *Monthly Notices* and in the Bulletin of the Committee.

In conclusion, it will be of interest to give the development of the formulas (3) in ascending powers of the hour-angle. The development is obtained at once from the equations contained in my article in No. 350 of the *Journal*.

$$\begin{aligned}
\omega_1 &= k \sin 1'' & \log k \sin 1'' &= 6.4532-10\\
\omega_2 &= k \cos^2 q \sec^2(q-\delta) \sin^2 1^{\mathrm{m}} \sin 1'' & \log k \sin^2 1^{\mathrm{m}} \sin 1'' &= 1.7328-10\\
\omega_3 &= \tfrac{1}{15} k \sin(q-2\delta) \cos q \sec^2\delta \sec^2(q-\delta) \sin 1^{\mathrm{m}} \sin 1'' & \log \tfrac{1}{15} k \sin 1^{\mathrm{m}} \sin 1'' &= 2.9169-10\\
\omega_4 &= \tfrac{15}{2} k \sin 2q \sec^2(q-\delta) \sin 1^{\mathrm{m}} \sin 1'' & \log \tfrac{15}{2} k \sin 1^{\mathrm{m}} \sin 1'' &= 4.9681-10\\
\omega_5 &= k \sec^2(q-\delta) \sin 1'' & \log k \sin 1'' &= 6.4532-10\\
\omega_6 &= \tfrac{1}{15} \omega_4 \tan(q-\delta) \sin 1^{\mathrm{m}} & \log \tfrac{1}{15} \sin 1^{\mathrm{m}} &= 6.4637-10
\end{aligned}$$

$$\begin{aligned}
M_x &= \omega_1 + \omega_2 t^2 & M_y &= \omega_4 t\\
N_x &= \omega_3 t & N_y &= \omega_5 + \omega_6 t^2
\end{aligned}$$

$$\begin{aligned}
\text{Refr. corr. for } X \sec\delta &= M_x X \sec\delta + N_x Y\\
\text{Refr. corr. for } Y &= M_y X \sec\delta + N_y Y
\end{aligned}$$

MERIDIAN-CIRCLE OBSERVATIONS OF COMPARISON-STARS FOR PERIODIC COMET *c* 1896,

BY R. H. TUCKER.

The places of the following stars have been determined for Prof. Hussey's observations of this periodic comet. They may be useful to other observers, since they lie in a region through which the comet moved slowly.

The fourth star, 6175, is 9^M, no other magnitude-difference being noted by me.

DM. No.	DM. Mag.	1896 α	1896 δ
°		h m s	° ′ ″
19 6271	9.5	22 19 50.02	−19 12 12.5
19 6275	8.0	20 38.32	−19 5 32.6
19 6276	9.2	20 48.01	−19 12 12.9
18 6175	9.3	37 27.09	−18 35 45.0
18 6176	8.5	37 39.33	−18 23 23.6
18 6178	8.3	22 38 13.23	−18 8 42.6

Lick Observatory, 1896 *Sept.* 30.

ELLIPTIC ELEMENTS AND EPHEMERIS OF COMET *d* 1896 (*GIACOBINI*),

BY W. J. HUSSEY AND C. D. PERRINE.

From the following observations

Mt. Hamilton M.T.		App. α	App. δ
	d h m s	h m s	° ′ ″
Sept.	5 8 13 13	17 13 5.02	− 7 42 47.1
	11 10 35 23	17 25 7.74	− 8 41 47.1
	28 9 3 19	18 4 58.67	−11 12 24.5

we have computed the following elliptic elements of this comet.

Epoch 1896 Sept. 5.5 Gr. M.T.

$$\begin{aligned}
M &= 354^\circ\ 43'\ 37''\\
\Omega &= 191\ \ 44\ \ 13\\
\omega &= 139\ \ \ 5\ \ 28\\
i &= \ \ 11\ \ 35\ \ 18
\end{aligned}\Bigg\}\ \text{Eq. } 1896.0$$

$$\begin{aligned}
\log e &= 9.82189\\
\log a &= 0.64636\\
\log \mu &= 2.58047\\
\text{Period} &= 9.323 \text{ years}
\end{aligned}$$

Constants for the Equator.

$$\begin{aligned}
x &= r[9.99964] \sin(v + 60^\circ\ 35'\ 53'')\\
y &= r[9.99024] \sin(v + 330\ \ \ 5\ \ 47)\\
z &= r[9.32917] \sin(v + 341\ \ 23\ \ 26)
\end{aligned}$$

These observations are also satisfied by the following remarkable system of elements.

Epoch 1890 Sept. 0.0 Gr. M.T.

$$\begin{aligned}
M &= 286^\circ\ 26'\ 48''\\
\Omega &= 216\ \ 34\ \ 53\\
\omega &= 190\ \ 49\ \ 45\\
i &= \ \ \ 7\ \ 34\ \ 29
\end{aligned}\Bigg\}\ 1896.0$$

$$\begin{aligned}
\log e &= 9.29718\\
\log a &= 0.09470\\
\log \mu &= 3.40796\\
\text{Period} &= 510 \text{ days}
\end{aligned}$$

The last elements, however, do not satisfy later observations.

Ephemeris for Greenwich Mean Midnight.

1896	App. α	App. δ	log *r*	log Δ	Br.
	h m	° ′			
Oct. 22.5	19 14.0	−13 29.4	0.173	0.124	0.87
24.5	20.3	−13 34.9			
26.5	26.6	−13 39.5	0.173	0.130	0.85
28.5	33.1	−13 43.1			
30.5	39.5	−13 45.6	0.173	0.137	0.82
Nov. 1.5	46.0	−13 47.2			
3.5	52.6	−13 47.6	0.174	0.144	0.79
5.5	19 59.2	−13 46.8			
7.5	20 5.8	−13 45.0	0.175	0.151	0.76
9.5	12.4	−13 42.1			
11.5	20 19.0	−13 38.1	0.177	0.159	0.73

Mt. Hamilton, Cal., 1896 *Oct.* 13.

OBSERVATIONS OF SMALL PLANETS,

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 12-INCH EQUATORIAL.

By Professor EDGAR FRISBY.

[Communicated by Prof. Wm. Harkness, U.S.N., Astronomical Director.]

1896 Washington M.T.	*	No. Comp.	Planet − * $\Delta\alpha$	Planet − * $\Delta\delta$	Planet's apparent α	Planet's apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
(287) *Nephthys.*								
h m s			m s	′ ″	h m s	° ′ ″		
July 25 12 10 31.8	1	10 , 2	+3 18.34	−7 28.3	19 59 31.43	−14 2 52.8	8.7398	0.8465
Aug. 3 11 41 42.1	2	20 , 4	−0 46.20	−0 53.5	19 51 34.74	−15 16 6.1	8.9502	0.8521
6 11 13 28.9	3	5 , 1	−2 56.66	+5 38.8	19 49 10.48	−15 40 18.6	8.7810	0.8554
11 11 46 47.2	4	10 , 2	−3 16.70	−9 4.8	19 45 33.45	−16 20 3.0	9.2435	0.8517
19 9 43 32.8	5	20 , 4	−0 8.96	+0 53.1	19 41 5.67	−17 18 58.6	*n*7.6047	0.8660
(386).								
July 25 12 53 49.0	6	20 , 4	+0 15.96	−2 48.0	20 51 56.89	+ 2 24 29.9	8.5225	0.7186
31 12 14 7.7	7	15 , 3	+3 39.02	−5 19.6	20 50 34.97	+ 1 36 39.8	7.9557	0.7267
Aug. 3 13 19 43.3	8	20 , 4	+1 57.93	+3 37.2	20 48 17.50	+ 1 11 32.6	9.2003	0.7316
19 10 18 13.4	9	20 , 4	+3 53.10	−7 2.3	20 36 54.90	− 1 34 56.2	*n*8.6600	0.7542
(346).								
Aug. 11 13 9 13.5	10	20 , 4	+0 17.99	+8 6.8	20 40 28.17	−21 4 8.0	*n*8.1065	0.8828

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	19 56 9.02	+4.07	−13 55 29.9	+ 5.4	*Berliner Jahrbuch*
2	19 52 16.83	+4.11	−15 15 19.1	+ 6.5	Washington A.G. Zones
3	19 52 3.03	+4.11	−15 46 2.7	+ 5.3	Radcliffe (1890) 5333
4	19 48 45.98	+4.17	−16 11 2.5	+ 4.3	Weisse's Arg. 15768
5	19 41 10.44	+4.19	−17 19 55.8	+ 4.1	Radcliffe (1890) 5280
6	20 54 37.26	+3.67	+ 2 27 8.0	+ 9.9	Boss, Albany A.G. Catal. 7359
7	20 46 52.23	+3.72	+ 1 41 49.2	+10.2	Boss, Albany A.G. Catal. 7308
8	20 46 15.80	+3.77	+ 1 7 41.9	+10.5	Boss, Albany A.G. Catal. 7302
9	20 32 57.90	+3.90	− 1 28 5.3	+11.4	Radcliffe (1890) 5549
10	22 40 6.01	+4.17	−21 12 36.3	+21.5	Weisse's Arg. 17580

NEW ASTEROID.

Prof. Kreutz has communicated the position of a new planet, found photographically by Witt, of the *Urania* Observatory at Berlin.

DA $11\frac{1}{2}^{M}$ Oct. 8 $11^{h}\ 27^{m}$, Berlin M.T. $\alpha = 1^{h}\ 41^{m}.6$, $\delta = +13^{\circ}\ 26'$

It was observed with the large *Urania* refractor

Oct. 9 $13^{h}\ 0^{m}$, Berlin M.T. $\alpha = 1^{h}\ 43^{m}\ 36^{s}$, $\delta = +13^{\circ}\ 30'$

No. 324 discovered by Palisa 1892 Feb. 25 has received the name *Bamberga*.

NOTICE.

Mr. C. D. Perrine of the Lick Observatory requests that any unpublished observations of the Comet 1895 IV, discovered by him, be made public, or sent him at an early date.

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Ephemeris of Long-Period Variables for 1897, by Dr. S. C. Chandler.
Short Formulas for Gauss's Method of Computation of an Orbit from Three Complete Observations, by Rev. G. M. Searle.
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Elliptic Elements and Ephemeris of Comet *d* 1896 (Giacobini), by Prof. W. J. Hussey and Mr. C. D. Perrine.
Observations of Small Planets, by Prof. Edgar Frisby.
New Asteroid.
Notice.

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NOTES ON VARIABLE STARS, — No. 15,

By HENRY M. PARKHURST.

S Herculis. It seems impossible to satisfactorily represent all the observations by one sine formula. There appears to have been a retardation in the periodic changes from about 1870. Making the sine-formula in the Second Catalogue $50((12.5-0.1E)^\circ E + 90^\circ)$ gives an approximation for the last 50 years, especially for the last 20 years. But for purposes of prediction and comparison I suggest the simple form $307.6 + 50(5^\circ E + 225^\circ)$, which represents the observations since 1868 without appreciable systematic error, although for earlier dates the deviation is very great.

RESULTS OF OBSERVATIONS.

No.	Star	Phase	Observed Date		E	Corr.	W	Remarks
			Julian	Calendar				
5194	*V Bootis*	Max.	3762.8	July 21	17	− 9	9	
5237	*R Bootis*	Max.	3688	May 8	62	+ 2	7	
"	"	Min.	3795	Aug. 23	63	−15	7	
5249	*V Librae*	Max.	3689:	May 9	14	+83	2	Possibly earlier. The new elements inconsistent with my obsns. of last year. A period of 256 days suggested
5405	*RT Librae*	Max.	3776:	Aug. 4	–	–	3	Probably later
5430	*T Librae*	Max.	3767	July 26	28	− 2	4	
5438	*Y Librae*	Max.	3719	June 8	47	−14	6	(+65). The new elements nearly satisfy all obsns.
5501	*S Serpentis*	Max.	3738.4	June 27	68	+20	9	(+33)
5511	*RS Librae*	Min.	3712	June 1	12	−19	1	Assuming min. midway
5566	*RU Librae*	Max.	3688	May 8	9	+ 8	1	I had intended to suggest period of 328 days
5593	*W Librae*	Max.	3705	May 25	32	−19	3	
5617	*U Librae*	Max:	3732	June 21	37	0	8	
5675	*V Coronae*	Max.	3698	May 18	18	+ 2	7	
5688	*R Librae*	Max.	(3698)	May 18	–	–	0	My suggested period not verified. Too faint for recognition May to Aug. Obsns. not yet reduced
5795	*W Scorpii*	Max.	3711	May 31	33	−25	2	Probably still earlier
5928	*T Ophiuchi*	Max.	–	–	–	–	–	Suspected; very faint; obsns. not yet reduced
5931	*S Ophiuchi*	Max.	3744	July 3	61	−12	5	
6044	*S Herculis*	Max.	3706	May 26	47	+23	5	(+62) −2, by elements given above
6132	*R Ophiuchi*	Max.	3712	June 1	47	−21	2	(−31). Possibly earlier. Confirms corr. of *A.J.* 365
6207	*Z Ophiuchi*	Min.	3810	Sept. 7	4	− 7	7	Comp.-stars reduced $0^M.68$ in equalization
6512	*T Herculis*	Max.	3799.9	Aug. 27	63	+ 8	9	Interval of 17 days in obs. at the maximum.
6682	*X Ophiuchi*	Max.	3743	July 2	11	− 3	7	Corr. for max. in *A.J.* 311, −79 by new elements
6733	*R Scuti*	–	–	–	–	–	–	1895. Observations by Perry

INDIVIDUAL OBSERVATIONS.

5194 *V Bootis.*

(Cont. from 356. Comp. Stars 333)

Julian	Calendar	Mag.
3753.6	July 12	7.40_2
3755.6	14	8.37_2
3758.6	17	8.08_2
3759.6	18	8.25_2

5194 *V Bootis.* — Cont.

Julian	Calendar	Mag.
3762.6	July 21	7.93_2
3766.6	25	8.20_2
3771.6	30	8.20_2
3774.6	Aug. 2	8.35_2

5237 *R Bootis.*

(Cont. from 356 Comp Stars 333)

Julian	Calendar	Mag.
3655.6	Apr. 5	9.22_2
3684.5	May 4	7.72_2
3687.6	7	7.72_2
3690.6	10	7.71_2

5237 *R Bootis.* — Cont.

Julian	Calendar	Mag.
3693.6	May 13	7.9P
3695.6	15	7.68_2
3704.6	24	8.27_2
3707.6	27	7.92
3709.6	29	8.5P

5237 *R Bootis.* — Cont.

Julian	Calendar	Mag.
3711.6	May 31	8.72_2
3714.7	June 3	8.6P
3716.6	5	8.8P
3722.6	11	9.30
3733.6	22	10.68_2

5237 *R Bootis.*—Cont.

Julian	Calendar		Mag.
3743.6	July	2	10.45
3753.6		12	11.36$_2$
3774.6	Aug.	2	12.08$_2$
3780.6		8	12.83$_2$
3807.5	Sept.	1	12.16$_2$
3813.5		10	12.20$_2$
3833.5		30	10.89$_2$

5249 *V Librae.*

(Continued from 356)

3684.6	May	4	10.4
3688.6		8	10.11$_2$
3689.7		9	10.05$_2$
3699.6		19	10.70$_2$
3707.6		27	10.18$_2$
3711.6		31	11.28$_2$
3723.6	June	12	12.36$_2$
3752.6	July	11	13.0]

5405 *RT Librae*

3684.6	May	4	to
3710.6	June	29	12.8]
	6 dates		
3752.6	July	11	11.3
3772.6		31	9.51$_2$
3776.6	Aug.	4	8.13$_2$
3777.6		5	8.0
3778.5		6	8.44$_2$

5130 *T Librae*

(Continued from 356)

3711.6	May	31	11.5]
3723.6	June	12	12.0]
3740.6		29	12.1
3741.6		30	12.19$_2$
3752.6	July	11	11.4
3772.6		31	10.26$_2$
3777.6	Aug.	5	10.1
3778.5		6	10.63$_2$

5438 *Y Librae*

(Cont. from 356. Comp. Stars 333)

3655.6	Apr.	5	11.4]
3684.6	May	4	11.7

5438 *Y Librae.*—Cont.

Julian	Calendar		Mag.
3688.6	May	8	11.38$_2$
3695.6		15	11.3
3711.6		31	9.63$_2$
3721.6	June	10	9.69$_2$
3729.6		18	9.46$_2$
3731.6		20	9.91$_2$
3733.6		22	10.83$_2$

5501 *S Serpentis*

(Continued from 356)

3688.6	May	8	11.21$_2$
3695.6		15	9.60$_2$
3704.6		21	9.87$_2$
3709.6		29	8.86$_2$
3711.6	June	3	8.69$_2$
3721.6		10	9.01$_2$
3723.7		12	8.72$_2$
3729.6		18	8.57$_2$
3731.6		20	8.50$_2$
3733.6		22	8.36$_2$
3740.6		29	8.43$_2$
3746.6	July	5	8.43$_2$
3753.6		12	8.96$_2$
3759.6		18	9.13$_2$

5511 *RS Librae*

(Continued from 356)

3684.6	May	4	11.1
3690.7		10	11.1
3695.7		15	11.1
3709.6		29	12.8
3721.6	June	10	12.3
3723.6		12	12.0
3740.5		29	8.7P:
3740.6		29	11.4
3752.6	July	11	11.0
3774.6	Aug.	2	10.4P

5566 *RU Librae*

3688.6	May	8	8.3
3689.6		9	8.38$_2$
3707.6		27	9.20$_2$

5593 *W Librae*

Julian	Calendar		Mag.
3688.6	May	8	11.4
3709.6		29	11.9
3712.6	June	1	11.46$_2$
3714.6		3	11.86$_2$
3715.6		4	12.23$_2$
3723.6		12	12.40$_2$

5617 *U Librae*

(Continued from 308)

3688.6	May	8	10.0]
3709.6		29	10.6
3712.6	June	1	10.23$_2$
3715.6		4	10.00$_2$
3721.6		10	9.54$_2$
3729.6		18	9.19$_2$
3741.6		30	9.40$_2$
3752.6	July	11	9.88$_2$
3758.6		17	9.98$_2$

5675 *V Coronae*

(Continued from 356)

3684.6	May	4	9.22$_2$
3688.5		8	9.30$_2$
3695.6		15	8.96$_2$
3704.6		24	8.87$_2$
3709.6		29	9.53$_2$
3712.6	June	1	9.32$_2$
3716.6		5	9.3P

5795 *W Scorpii*

(Continued from 308)

3711.7	May	31	11.2
3712.6	June	1	11.43$_2$
3715.7		4	11.64$_2$
3721.6		10	11.93$_2$
3740.6		29	12.2

5931 *S Ophiuchi*

(Continued from 333)

3711.6	May	31	12.0
3716.6	June	5	10.14$_2$
3729.6		18	10.1

5931 *S Ophiuchi*—Cont.

Julian	Calendar		Mag.
3740.6	June	29	9.55$_2$
3753.6	July	12	9.30$_2$
3772.6		31	10.37$_2$

6044 *S Herculis*

(Continued from 365)

3699.6	May	19	7.96$_2$
3701.6		21	7.38$_2$
3707.6		27	7.84$_2$
3709.6		29	7.48$_2$
3716.7	June	5	7.6P
3740.6		29	8.1P

6132 *R Ophiuchi.*

(Continued from 365)

3711.7	May	31	7.5
3712.6	June	1	7.50$_2$
3713.6		2	7.63$_2$
3714.6		3	8.02$_2$
3716.6		5	7.54$_2$
3722.7		11	7.88$_2$
3729.6		18	8.21$_2$
3740.6		29	8.29$_2$
3746.6	July	5	8.66$_2$

6207 *Z Ophiuchi.*

(Cont. from 365. Comp. Stars 333)

3687.7	May	7	8.9
3690.7		10	9.87$_2$
3713.6	June	2	9.92$_2$
3714.6		3	9.81
3715.6		4	10.20
3716.6		5	10.61
3722.6		11	10.40
3742.6	July	1	11.23$_2$
3774.6	Aug.	2	12.00$_2$
3787.6		15	12.4
3807.5	Sept.	4	13.37$_2$
3813.6		10	13.61$_2$
3833.5		30	13.05$_2$
3842.5	Oct.	9	12.19$_2$
3858.5		25	13.4

6512 *T Herculis.*

(Continued from 365)

Julian	Calendar		Mag.
3743.7	July	2	11.8P
3762.6		21	9.8
3774.6	Aug.	2	9.17$_2$
3774.6		2	9.2P
3780.6		8	8.70$_2$
3786.5		14	8.28$_2$
3787.7		15	8.0P
3789.5		17	7.98$_2$
3789.7		17	7.8P
3790.5		18	8.01$_2$
3797.6		25	7.8P
3798.6		26	8.0P
3799.6		27	8.0P
3801.6		29	8.0P
3804.6	Sept.	1	8.0P
3807.6		4	8.20$_2$
3807.6		4	8.1P
3809.6		6	8.1P
3813.6		10	8.3P
3814.5		11	8.81$_2$
3814.6		11	8.3P
3820.5		17	8.84$_2$
3821.5		18	8.98$_2$

6682 *X Ophiuchi*

(Continued from 365)

3740.7	June	29	6.68$_2$
3741.6		30	6.22$_2$
3742.6	July	1	6.51$_2$
3743.6		2	6.36$_2$
3743.6		2	6.6P
3746.6		5	6.29$_2$
3752.6		11	6.75$_2$
3774.6	Aug.	2	6.8P

6733 *R Scuti*

3513.5	Nov.	15	5.3P
3515.5		17	5.6P
3516.5		18	5.3P
3517.5		19	5.5P
3520.5		22	5.2P
3525.5		27	5.3P

COMPARISON-STARS.

5249 *V Librae.*

N	−17°4141	9.13	2
1*N*	−17°4133	9.65	1
P	−16°3914	8.60	2
S	−17°4136	9.48	6
V	−17°4146	9.88	5
W	−16°3911	11.02	7
Y	−16°3907	11.84	1
Z	−16°3905	12.16	1
i	7*f* *V*	12.19	3
k	6*f* *i*	12.49	2

5501 *S Serpentis.*

1893–1896

F	+15°2845	7.71	16
H	+14°2866	8.56	19
J	+15°2855	8.39	6
N	+14°2868	9.28	18
T	+15°2846	9.64	6
2*T*	+14°2869	9.89	9
2*V*	+14°2870	10.39	5
X	+14°2862	10.22	6
b	5*n*5*p* *H*	10.86	3
f	2*s*8*p* *X*	11.57	4

5511 *RS Librae.*

N	−22°3938	8.24	2
1*N*	−22°3943	8.03	7
R	−22°3948	8.73	9
T	−22°3951	9.08	10
W	−22°3954	10.36	1
Y	−22°3952	10.53	2
e	3.3*s* 0.7*f* *Y*	11.06	1
m	1.2*n* 2.1*p* *V*	13.0	0
n	1*n* 1*f* *m*	13.2	0

6044 *S Herculis.*

1893–1896

E	+15°3077	7.11	18
1*F*	+16°3051	7.20	22
1*H*	+15°3072	7.36	31
KF	+15°3074	7.99	26
N	+15°3070	8.26	25
R	+15°3069	8.83	4
S	+15°3060	9.09	13
1*S*	+15°3075	8.94	16
Y	+15°3073	10.45	6
Z	+15°3064	11.13	6

COMPANION OF *SIRIUS*.

Prof. Edward S. Holden of the Lick Observatory telegraphs from there.

“Clark's companion to *Sirius* is in its predicted place. Position 189°, distance 3″.7, from three nights' measure by Aitken and Schaeberle. No other companion is visible.”

MEASURES OF *SIRIUS*,

MADE WITH THE 36-INCH EQUATORIAL OF THE LICK OBSERVATORY,

By R. G. AITKEN.

On Saturday morning, October 24, I turned the large equatorial of this Observatory upon *Sirius*, and saw the companion. Since then I have made two additional measures, and Professor SCHAEBERLE has made two, which he has kindly given me, to publish with mine.

Neither of us saw any star in the position given by Dr. SEE (*A.J.* 385).

Our measures are,

1896 P.S.T.	θ	ρ ″	Seeing	Observers
Oct. 23.65	189.0	3.81	5	Aitken
28.65	188.5	3.57	3	Aitken
28.65	188.3	3.65	3	Schaeberle
30.60	190.0	3.65	5	Schaeberle
30.65	190.6	[4 ±]est.	4	Aitken

Mt. Hamilton, 1896 *Oct* 31.

OBSERVED MAXIMA OF VARIABLE STARS,

By PAUL S. YENDELL.

6225. *RS Herculis.*

From 1896 June 10 to October 26, I observed this star thirty-two times. At the first date it was just steadily held, on a clear sky, and its brightness estimated as $12^{\rm M}$. A maximum of $8^{\rm M}.3$ was passed August 1, followed by a sharp decrease to $8^{\rm M}.6$ on August 13, and a well-marked secondary maximum of $8^{\rm M}.4$ on August 24, after which date it steadily declined, its light at the last observation being estimated as below $11\frac{1}{2}^{\rm M}$.

6549. *W Lyrae.*

Since the announcement of the confirmation of this star's variability, it has been kept under observation. A maximum of $8^{\rm M}.2$ is indicated on September 13. When last seen, on October 31, it had fallen to $9^{\rm M}.3$.

6871. *V Lyrae.*

This star was first seen on 1896 August 28, and its brightness estimated as $9^{\rm M}.7$. It rose to a maximum of $9^{\rm M}.2$, which is indicated on September 14. On October 9 it had fallen to $9^{\rm M}.7$, and on October 31, when last observed, seemed to be nearly stationary at that brightness.

7085. *RT Cygni.*

Eighteen observations of this star, from 1896 May 7 to September 30, indicate a maximum on July 17, the greatest observed brightness being $7^{\rm M}.4$. Its decrease was rapid, and at the last observation the star was estimated as $11^{\rm M}.4$.

7118. *X Aquilae.*

Eleven observations, from 1896 June 10 to August 8, indicate a faint maximum of $10^{\rm M}.2$ on July 1. At the last date, it was just held, and estimated at $12^{\rm M}$.

7192. *Z Cygni.*

This star was observed on fifteen dates, from 1896 June 30 to September 30. A maximum is shown on August 1, the greatest observed brightness being $7^{\rm M}.7$. At the last observation, it had decreased to $9\frac{1}{2}^{\rm M}$.

7240. *RY Cygni.*

Eleven observations, from 1896 May 13 to October 31, indicate a maximum of about $9^{\rm M}.2$, on September 4. At the last observation, the star had fallen to about $10^{\rm M}.3$.

8068. *S Lacertae.*

Sixteen observations, from 1896 July 30 to October 7, show a maximum of $8^{\rm M}.4$ on September 9. Its brightness when first observed was $9^{\rm M}.6$, and at the last date, $9^{\rm M}.0$. The star's light was sensibly stationary from August 28 to September 20, both the increase and decrease being rather rapid.

8369. *W Pegasi.*

Twelve observations, from 1896 August 17 to October 31, show a well-defined maximum of $8^{\rm M}.4$ on September 21. The star's brightness at the first observation was $9^{\rm M}.6$, and at the last $9^{\rm M}.1$.

Dorchester, Mass., 1896 *Nov.* 6.

CATALOGUE NO. 1 FOR 1900.0 OF NEBULAS,

DISCOVERED AT THE LOWE OBSERVATORY, CALIFORNIA,

By LEWIS SWIFT.

Since the removal of my astronomical instruments from the Warner Observatory, Rochester, N.Y., to the Lowe Observatory, Echo Mountain, Cal., I have, besides entertaining visitors, devoted much time to comet-seeking with my $4\frac{1}{2}$-inch, and as a pastime, that an old habit may not entirely languish, have also at odd spells continued my former work searching for new nebulas, resulting in the following list.

My low latitude +34° 20′, enables me to work in fields beyond the reach of Sir WILLIAM HERSCHEL, or of his son Sir JOHN, except while sojourning at the Cape of Good Hope.

Scarcely any can be classified as bright, and but very few are as bright as HERSCHEL's Class II, while the large majority are much fainter than his Class III, and therefore visible only during exceptionally fine seeing, and, with large telescopes, and by an eye long trained to this kind of work.

The eyepiece used is a periscopic by the Gundlach Optical Co. of Rochester, N.Y., giving a magnifying power of 132, and a field of 32′. Its large flat field renders it admirably adapted for nebula-work, and for comet-seeking it cannot be excelled.

No.	Date of Discovery	α	δ	Description
		h m s	° ′ ″	
1	Sept. 12, 1896	0 1 40	− 4 19 10	pB. vS. vE.
2	Dec. 8, 1895	0 18 3	+ 6 25 35	eeF. unequal D*f 46^s same parallel
3	Sept. 10, 1895	0 30 0	−10 7 0	eeeF. pS.R. eedif.
4	5, 1896	0 38 30	− 4 41 53	eeF. S.R. 10^M * close s. Not 239
5	Dec. 18, 1895	0 53 22	−12 43 17	eeF. pS. nearly bet a 7^M * p. and a 9^M * nf. near th latter
6	13, 1895	0 56 40	−16 9 6	pF. S.R. 9^M * nearly in contact np.
7	Oct. 6, 1896	1 12 45	−17 38 12	eF. 8^M in field nf. pS.R. no star near
8	Dec. 18, 1895	1 14 20	−17 22 28	vF. pS. lE. wide D* near nf. f of 2
9	18, 1895	1 14 40	−17 37 25	eeF. vS.R. p a 7^M * nf. 17^s. p of 2
10	Oct. 12, 1896	1 20 30	+16 4 42	eeeF. pS. lE. bet 2 st in meridian. Wide D* in field nf. eedif.
11	8, 1896	1 43 10	−27 26 42	pB. eeS. almost stellar. In vacancy
12	Dec. 8, 1895	1 46 45	−10 20 0	eeeF. vS. G.C. 418 p
13	18, 1895	1 55 5	−11 36 25	eeF. pS. bet th 2 southern of 4 stars forming a trapezium
14	Oct. 8, 1896	1 56 8	−25 34 40	eeeF. pS.R. 3 9^M st near sf. form an equilateral triangle. eedif.
15	8, 1896	2 2 55	−25 57 32	vFD * in neby. both st = m. but of extreme faintness. Curious object
16	12, 1896	2 11 20	−12 24 55	eeF. eeE. bet 2 st p and f. 8^M * near nf. a ray.
17	12, 1896	2 27 50	−37 11 40	vF.S.R. Wide D* near np
18	Sept. 16, 1896	3 0 20	−27 52 35	eF. vS.R. F* near sf
19	Oct. 8, 1896	3 5 8	−25 42 30	eeF. pS. 2 stars in meridian close p
20	8, 1896	3 36 45	−22 55 35	vF. pS.R. Not G.C. 765
21	5, 1896	3 37 1	−18 32 20	eeF. S.R. in vacancy
22	5, 1896	3 51 1	−28 30 25	eF. v.S. eeeF* v close nf
23	5, 1896	4 10 32	−33 22 25	eeeF. eS. B*f. 1532 p. eedif. 3 in field including D neb
24	Dec. 10, 1895	4 23 3	−42 23 15	eF. pL.R. 3 stars like belt of *Orion* point to it. p of 2
25	Oct. 5, 1896	4 41 2	−34 10 13	vF. pS.R. 3 stars in line near sp nearly point to it
26	13, 1896	5 27 30	−23 14 40	eF. pS.R. 8^M * near nf
27	16, 1896	5 27 40	−17 20 3	pF. vS.R. between 2 stars p and f
28	Dec. 9, 1895	5 29 35	−26 30 45	vF. pS. eE. almost a ray. 1963 p [no * in field p
29	May 26, 1895	15 15 10	−23 19 50	eeeF. vL. not 5898 nor 5903 vdif. bet 2 wide D st vr and s 10^M * nrf
30	Aug. 12, 1896	20 58 49	+11 25 15	eeeF. vS. p 8^M * 13^s p and f. Wide D * near n. eedif.
31	Sept. 12, 1896	21 25 40	+11 20 15	eeF. vS. F* near f. Not 7068
32	Aug. 8, 1896	22 15 19	−14 54 5	vF. eE. a ray. p of 2
33	8, 1896	22 16 30	−19 25 20	eeeF. vS.R. f below * 15^s. little s. f of 2
34	June 8, 1896	22 16 15	−19 23 20	eF.S.R. nr n of fol * of 7 in a line p and f. p of 2
35	Aug. 8, 1896	22 26 54	−14 38 5	pB. pS.R. pB* near s.f of 2
36	Sept. 12, 1896	22 49 10	−20 55 15	eeeF. pL.R. f 9^M * same parallel 22^s. eedif.
37	2, 1896	22 51 5	−37 8 48	vF.S. eeE. a ray sp of below stars. sf of 2
38	2, 1896	22 51 10	−37 3 45	B.CL.R. bet 2 st p and f. np of 2
39	2, 1896	22 52 0	−36 27 40	vF. pS.R. np of 2
40	Aug. 12, 1896	22 52 5	−36 37 40	vF. pS. vE. sf of 2
41	12, 1896	22 53 40	−38 17 50	pF.CL.lE. 2 wide D stars near p
42	Sept. 10, 1896	23 5 30	−33 5 15	a few eeeF. st in neb.
43	13, 1896	23 21 0	−18 36 0	eF. vS.R. F* p close np
44	14, 1896	23 24 10	−29 25 57	eeeF. S. vE. 8^M * p
45	14, 1896	23 41 40	−28 32 55	eeeF. eS. R. 9^M * near f same parallel. 1st of 5
46	14, 1896	23 42 0	−28 42 16	eeF. S.R. a 6^M * with dis. com. f. 2nd of 5
47	14, 1896	23 12 5	−28 42 56	eeF. S.R. 3d of 5
48	14, 1896	23 42 20	−28 43 55	eeF. pS. E. 4th of 5
49	14, 1896	23 45 0	−28 54 57	eeF. pS. nrly bet an 8^M * nf and a 9^M * sp nearer the former 5th of 5
50	15, 1896	23 51 0	−29 37 55	vF. pS.R. 8^M * near sf

REMARKS.

15. Found searching for Comet 1889 V (Brooks), after POOR's ephemeris. Saw again June 10, 1896.

33. Found searching for BROOKS's Comet 1889 V. 34. Found searching for BROOKS's Comet 1889 V.

41. Neither this nor the four preceding nebulas are in Dreyer's N.G.C. No. 38 may possibly = no. 1459 of Dreyer's Index-Catalogue.

OBSERVATIONS OF COMET *d* 1896 (*GIACOBINI*),

MADE AT THE LICK OBSERVATORY,

BY W. J. HUSSEY AND C. D. PERRINE.

1896 Mt. Hamilton M.T.		*	No. Comp.	☄ − *		☄'s apparent		log pΔ		Obs.
				Δα	Δδ	α	δ	for α	for δ	
	h m s			m s	′ ″	h m s	° ′ ″			
Sept. 9	10 19 39	3*a*	*d*10 , 8	+0 20.90	+2 3.2	17 21 0.76	− 8 22 41.1	9.631	0.758	P
10	10 5 13	4	15 , 6	+0 23.44	+2 20.4	17 23 1.39	− 8 31 56.4	9.619	0.762	H
11	9 51 44	6	5	. . .	+6 3.7	. . . .	− 8 41 31.2	. .	0.766	H
	10 35 23	6	6	+0 23.69	. .	17 25 7.71	. . . .	9.646	. .	H
28	8 50 36	7	*d* 7 , 9	−0 23.45	−5 16.7	18 4 57.07	−11 12 18.4	9.565	0.786	H
	9 16 3	7	*d* 6 , 9	−0 20.25	−5 28.9	18 5 0.27	−11 12 30.6	9.600	0.777	P
29	7 31 46	9	*d* 7 , 7	−0 7.31	−1 27.5	18 7 25.47	−11 19 30.0	9.365	0.809	H
	7 45 31	9	*d*10 , 8	−0 5.73	−1 35.3	18 7 27.05	−11 19 37.8	9.394	0.808	P
30	7 50 58	11	*d*10 , 8	+0 8.85	+0 2.5	18 10 5.93	−11 27 21.7	9.441	0.804	H
	8 8 34	11	*d*10 , 8	+0 10.87	−0 6.6	18 10 7.95	−11 27 30.8	9.489	0.803	P
Oct. 2	7 39 46	13	*d* 7 , 8	−0 15.32	+2 14.2	18 15 27.45	−11 42 16.3	9.423	0.788	H
3	7 1 32	15	*d* 8 , 8	−0 2.15	+2 46.2	18 18 7.04	−11 49 17.8	9.297	0.816	H
4	7 53 59	16	*d* 8 , 8	+0 4.93	+2 43.8	18 20 58.74	−11 56 39.2	9.468	0.805	H
	8 6 45	16	*d* 8 , 8	+0 6.58	+2 40.9	18 21 0.39	−11 56 42.2	9.498	0.801	P
7	7 34 7	18	*d* 8 , 8	−0 12.38	−0 49.1	18 29 22.22	−12 16 39.9	9.117	0.810	H
	7 50 10	18	*d*10 , 8	−0 10.44	−0 52.1	18 29 24.16	−12 16 42.6	9.465	0.806	P
	8 2 0	18	*d* 8 , 8	−0 9.41	−0 54.1	18 29 25.19	−12 16 44.9	9.494	0.799	H
	8 15 17	18	*d*10 , 9	−0 7.36	−0 57.9	18 29 27.24	−12 16 48.4	9.521	0.791	P
	8 36 8	18	*d* 8 , 8	−0 5.31	−1 5.8	18 29 29.29	−12 16 56.3	9.559	0.790	H
8	7 45 48	19	*d* 8 , 8	+0 3.53	+0 21.1	18 32 14.81	−12 23 3.0	9.456	0.803	H
	7 58 16	19	*d*10 , 8	+0 4.99	+0 15.7	18 32 16.27	−12 23 8.1	9.486	0.797	P
	8 10 42	19	*d*10 , 8	+0 6.50	+0 13.0	18 32 17.78	−12 23 11.1	9.513	0.796	H
	8 24 25	19	*d*10 , 8	+0 8.18	+0 9.0	18 32 19.46	−12 23 15.1	9.540	0.792	P

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
3*a*	17 20 36.86	+3.00	− 8 24 38.5	−5.8	Micrometer-comparison with 3*b*
3*b*	17 20 10.47	+3.00	− 8 34 42.1	−5.9	½(Munich$_2$ 6588 + Sj. 6222)
4	17 22 34.97	+2.98	− 8 34 11.0	−5.8	S.DM. −8°4445. Doub. Mean used. Con. with *5
5	17 20 10.54	+2.98	− 8 34 41.8	−5.8	Sj. 6222
6	17 24 41.05	+3.00	− 8 47 29.4	−5.5	Weisse's Bessel XVII. 399
7	18 5 17.51	+3.01	−11 6 58.4	−3.3	S.DM. −11°4550. Connected with *8
8	18 4 58.55	+3.01	−11 2 31.8	−3.3	Weisse's Bessel XVIII, 26
9	18 7 29.75	+3.03	−11 17 59.7	−2.8	Anon. Connected with *10
10	18 5 40.69	+3.02	−11 19 50.9	−3.0	Stone, Radcliffe Catalogue. 4749
11	18 9 54.05	+3.03	−11 27 21.5	−2.7	Anon. 12ᴹ ±. Connected with *12
12	18 11 0.96	+3.04	−11 26 5.3	−2.7	Munich (1), 15797. See notes
13	18 15 39.73	+3.04	−11 44 28.1	−2.4	S.DM. −11°4604. Connected with *14
14	18 16 48.66	+3.05	−11 54 37.0	−2.4	½(Munich (1), 16072 + Weisse's Bes. XVIII, 312)
15	18 18 6.16	+3.03	−11 52 1.6	−2.4	Anon. 12ᴹ ±. Connected with *14
16	18 20 50.79	+3.02	−11 59 20.6	−2.5	Anon. Connected with *17
17	18 17 23.05	+3.02	−12 3 54.6	−2.5	Argentine General Catalogue 25069
18	18 29 31.56	+3.04	−12 15 49.0	−1.5	Santini 2039
19	18 32 8.25	+3.03	−12 23 22.8	−1.3	S.DM. −12°5122. Connected with *20
20	18 31 43.32	+3.03	−12 26 8.1	−1.3	Stone 4882

NOTES.

Sept. 9. Seeing poor, windy.

Early in September, as seen in the 36-inch telescope, this comet had a fan-shaped tail about 1½′ in length, and a distinct brightening at the center of the coma. By the latter part of September its appearance had greatly changed, it had become fainter, much more diffuse and less definite in its outlines. It still retained its faint stellar nucleus. At times we had somewhat uncertain impressions of there being two nuclei.

Mt. Hamilton, Cal., 1896 *October* 23.

The observations of Sept. 9 and 28 were made with the 12-inch, and all the others with the 36-inch telescope. Except on September 10 and 11, the Δαs were measured directly with the micrometer. The declination of *12 is not that given by the Munich Catalogue, but that derived from a comparison with Stone, Radcliffe Catalogue, 4727. By this comparison Munich (1) 15797 appears to be in error 7″.4.

OBSERVATIONS OF COMET *c* 1896 (1889 V),

MADE AT THE LICK OBSERVATORY,

BY WILLIAM J. HUSSEY.

1896 Mt. Hamilton M.T.		⁎	No. Comp.	☄ − ⁎		☄'s apparent		log *p*Δ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
July 30	13 2 37	6	*d* 8 , 8	+0 4.88	−1 58.7	22 38 14.71	−18 30 48.6	*n*9.090	0.857
31	10 30 6	6	*d* 8 , 8	−0 8.22	−3 26.7	22 38 1.62	−18 32 16.6	*n*9.589	0.810
Aug. 1	10 31 21	8	*d* 8 , 8	+0 11.27	+1 24.6	22 37 45.29	−18 33 59.8	*n*9.581	0.812
2	10 48 24	8	*d* 8 , 8	−0 1.26	−0 18.7	22 37 26.77	−18 35 43.0	*n*9.481	0.822
	12 11 21	8	*d* 8 , 8	−0 5.07	−0 23.6	22 37 25.96	−18 35 47.9	*n*9.283	0.850
3	11 10 9	8	*d* 8 , 8	−0 24.43	−2 1.1	22 37 6.63	−18 37 28.5	*n*9.487	0.834
4	11 43 12	9	*d* 8 , 8	−0 24.19	−2 24.9	22 36 15.31	−18 39 17.6	*n*9.378	0.845
5	15 4 50	10	8	. . .	−3 50.4	. . . .	−18 41 16.1	. .	0.856
6	13 12 16	12	*d* 8 , 8	+0 1.11	+2 11.3	22 36 57.09	−18 43 1.0	*n*8.591	0.863
7	11 9 35	12	*d* 8 , 8	−0 19.13	+0 32.9	22 35 33.87	−18 44 39.3	*n*9.144	0.839
12	12 9 18	14	6	. . .	−5 16.4	. . . .	−18 53 27.5	. .	0.862
	12 39 58	15	*d* 8	+0 1.94	. .	22 33 3.23	. . . .	*n*8.713	
13	12 26 43	16	9 , 8	+2 53.56	+1 15.8	22 32 30.11	−18 55 8.1	*n*8.847	0.865
15	12 8 20	16	12 , 8	+1 41.03	−1 21.3	22 31 20.60	−18 58 15.1	*n*8.955	0.861
16	13 20 30	16	4	. . .	−2 49.1	. . . .	−18 59 42.9	. .	0.864
19	11 57 8	17	*d* 8	−0 23.05	. .	22 28 15.68	. . . .	9.468	
28	13 47 3	18	*d* 8 , 8	−0 0.69	+2 13.1	22 22 39.07	−19 8 57.8	9.384	0.841
31	9 8 3	20	*d* 8 , 8	−0 9.97	+3 36.3	22 20 42.42	−19 8 16.7	*n*9.483	0.837
Sept. 1	11 24 51	21	*d* 8 , 8	−0 11.28	+5 11.4	22 19 57.79	−19 7 13.3	*n*8.204	0.865
2	13 54 5	23	*d* 1 , 4	−0 3.87	−1 14.8	22 19 12.12	−19 6 51.6	9.173	0.833
3	11 58 3	24	4	. . .	−0 18.3	. . . .	−19 6 1.2	. .	0.860
	12 19 56	24	10	−2 8.26	. .	22 18 34.17	. . . .	9.090	
4	13 21 34	25	11 , 4	+2 4.71	−3 24.2	22 17 52.96	−19 4 52.1	9.407	0.846
5	12 10 29	25	10 , 8	+1 27.16	−2 10.6	22 17 15.41	−19 3 38.5	9.090	0.862
10	12 55 53	25	3	. . .	+7 20.9	. . . .	−18 54 4.4	. .	0.843

Mean Places for 1896.0 of Comparison-Stars.

⁎	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
2	22 38 13.23	. .	−18 8 42.6	. .	S.DM. −18°6178, mer. circ. determ. by Prof. TUCKER
6	22 38 5.95	. .	−18 29 10.4	. .	Anon. 11½ᴹ±. Connected with ⁎7
7	22 37 39.33	. .	−18 23 23.6	. .	S.DM. −18°6176, mer. circ. determ. by Prof. TUCKER
8	22 37 27.09	. .	−18 35 45.0	. .	S.DM. −18°6175 " " " " "
9	22 37 5.52	+3.98	−18 37 13.8	+21.1	Anon. 10½ᴹ±. Connected with ⁎8
10	22 35 57.1	+4.01	−18 37 46.5	+20.8	S.DM. −18°6171. Connected with ⁎11
11	22 40 27.91	+4.01	−18 38 56.6	+21.1	½(Munich (2) 12670+Weiss's Argelander 17581)
12	22 35 48.94	. .	−18 15 33.4	. .	Anon. 12ᴹ±. Connected with ⁎13.
13	22 38 22.36	. .	−18 49 34.8	. .	Munich (2) 12651
14	22 31 0.16	+4.16	−18 48 31.7	+20.6	Weiss's Argelander 17493
15	22 32 57.13	+4.16	−18 50 56.9	+20.8	Anon. 14ᴹ±. Connected with ⁎14
16	22 29 32.37	. .	−18 57 14.4	. .	Weiss's Argelander 17477
17	22 29 1.45	+4.28	−19 0 26.3	+20.7	Anon. 10ᴹ±. Connected with ⁎16
18	22 22 35.41	+4.35	−19 12 0.8	+19.9	Anon. Connected with ⁎19
19	22 23 11.31	+4.35	−19 15 12.0	+19.9	½(Munich (2) 12495+Cincinnati Z.C. 3785)
20	22 20 48.01	+4.38	−19 12 12.9	+19.9	S.DM. −19°6276, mer. circ. determ. by Prof. TUCKER
21	22 20 4.68	+4.39	−19 13 11.3	+19.6	S.DM. −19°6272. Connected with ⁎22
22	22 19 50.02	+4.39	−19 12 12.5	+19.6	S.DM. −19°6271, mer. circ. determ. by Prof. TUCKER
23	22 19 11.59	+4.40	−19 5 59.4	+19.6	Anon. 12ᴹ±. Connected with ⁎24
24	22 20 38.32	+4.40	−19 5 32.6	+19.6	S.DM. −19°6275, mer. circ. determ. by Prof. TUCKER
25	22 15 43.83	. .	−19 1 47.1	. .	Stone, Radcliffe Catalogue 6001

The observations of July 31, August 1, 2 (1st obs.), 3, 4, 7, 15, 16, 19, 31, and September 1, were made with the 12-inch, and the others with the 36-inch telescope. *d* indicates that Δα was measured directly with the micrometer. For ⁎6 the reductions to apparent place are for July 30, $+3^{s}.88$, $+20''.5$; July 31, $+3^{s}.89$, $+20''.7$; for ⁎8, Aug. 1, $+3^{s}.92$, $+20''.6$; Aug. 2, $+3^{s}.94$, $+20''.7$; Aug. 3, $+3^{s}.97$, $+20''.8$; for ⁎12, Aug. 6, $+4^{s}.04$, $+21''.1$; Aug. 7, $+4^{s}.06$, $+21''.2$; for ⁎16, Aug. 13, $+4^{s}.18$, $+20''.5$; Aug. 15, $+4^{s}.20$, $+20''.6$; Aug. 16, $+4^{s}.22$, $+20''.6$; for ⁎25, Sept. 4 and 5, $+4^{s}.42$, $+19''.2$; Sept. 10, ... $+21''.8$. Professor TUCKER has kindly determined the positions of a number of the stars with the meridian circle.

Mt. Hamilton, Cal., 1896 *Oct.* 29.

MICROMETER-MEASURES OF F. 70 *OPHIUCHI*,

MADE AT THE ROYAL OBSERVATORY, GREENWICH.

(Communicated by W. H. M. CHRISTIE, Astronomer Royal).

The following measures of F. 70 *Ophiuchi* were made with the 28-inch refractor, the full aperture of the object-glass being used. The power employed in the measures was 670, but a power of 1030 was used for examining the stars. The measures were made with a bifilar micrometer, the diameter of the spider-threads being 0″.07.

Date of Observation	Position Angle	Distance	Observers
	°	″	
1896.608	289.5	2.23	Mr. Dyson
1896.580	290.4	2.08	Mr. Lewis
.608	290.0	2.17	“
.619	290.2	2.11	“
.695	289.8	1.98	“
.742	290.0	2.06	“
1896.649	290.1	2.08	“

Date of Observation	Position Angle	Distance	Observers
	°	″	
1896.457	285.5	2.65	Mr. Bowyer
.559	283.5	2.42	“
.570	292.2	2.11	“
.638	290.3	2.20	“
.649	288.3	2.25	“
.660	288.7	2.37	“
1896.589	288.1	2.33	“
1896.619	290.9	2.18	Mr. Niblett

These measures agree with those given by Dr. See in the *A.J.*, No. 384 (though the position-angle is rather larger than his), in indicating a correction to Prof. Schur's orbit.

Royal Observatory, Greenwich, 1896 *Oct.* 5.

OBSERVATIONS OF COMET *f* 1896 (*PERRINE*),

MADE AT THE LICK OBSERVATORY, WITH THE 12-INCH EQUATORIAL,

BY C. D. PERRINE.

Mt. Hamilton M.T.	*	No. Comp.	☄ − *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Nov. 2 11 6 29	1	*d*10 , 10	+0 19.95	+5 40.6	20 21 36.33	+25 6 39.8	9.713	0.656
3 8 55 19	2	14 , 7	+2 13.23	+4 30.6	20 19 55.53	+24 21 7.2	9.613	0.491
4 6 27 32	3	*d*10 , 8	−0 23.77	−5 36.2	20 18 21.19	+23 36 53.2	9.176	0.340

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	20 21 14.09	+2.29	+25 0 39.5	+19.7	Becker, Berlin A.G. Catal. 7697
2	20 17 40.03	+2.27	+24 16 17.5	+19.1	Becker, Berlin A.G. Catal. 7666
3	20 18 42.68	+2.28	+23 42 10.2	+19.2	Becker, Berlin A.G. Catal. 7674

d in col. of compar. denotes $\Delta\alpha$ measured directly. Nov. 3. — High wind; seeing poor.

Comet is about 2′ in diameter, round, well marked condensation. It is about equal in brightness to a 10–11 mag. star. No tail.

COMET *f* 1896.

A faint comet was discovered by Perrine at the Lick Observatory, Nov. 2, $19^h\,13^m$, in right-ascension $20^h\,21^m\,36^s.3$, and decl. 25° 6′ 40″ N. Daily motion -2^m in α, and 45′ southward.

It has been since observed by Perrine.

$$1896 \text{ Nov. } 3.7215 \text{ Greenw. M.T.} \qquad \alpha = 20^h\,19^m\,55^s.5, \qquad \delta = +24^\circ\,21'\,5''$$
$$4.6070 \quad \text{“} \quad \text{“} \qquad 20\;18\;21.2 \qquad +23\;36\;53$$

Prof. Holden has telegraphed from the Lick Observatory. elements and ephemeris computed by Messrs. Hussey and Perrine from the foregoing observations.

ELEMENTS.

$$T = 1897 \text{ Jan. } 18.61$$
$$\left.\begin{aligned} \omega &= 133^\circ\;9' \\ \Omega &= 78\;44 \\ i &= 145\;53 \end{aligned}\right\} \text{Eq. } 1896.0$$
$$q = 1.5441$$

EPHEMERIS FOR GREENWICH MIDNIGHT.

	α	δ	Brightn.
	h m s	° ′	
1896 Nov. 6	20 15 16	+22 6	0.96
10	9 44	19 7	
14	5 20	16 24	
18	20 1 48	+13 57	0.83

Mr. HALM of Edinburgh has telegraphed the following:

ELEMENTS.

$T = 1897$ Feb. 7.56
$\omega = 168^\circ\ 28'$
$\Omega = 85\ 39$
$i = 146\ \ 7$
$q = 1.1162$

EPHEMERIS FOR GREENWICH MIDNIGHT.

	α	δ	
	h m s	° ′	
1896 Nov. 8	20 12 20	+20 38	1.0
12	20 7 12	+17 31	
16	20 3 0	+11 50	
20	19 59 36	+12 18	1.0

At the last moment before publication Mr. PERRINE's orbit has arrived with more detail, as also his observations in full, and the rectangular coordinates for the equator:

$$x = r[9.92185]\sin(v + 146^\circ\ 52'\ 29'')$$
$$y = r[9.98846]\sin(v + 245\ 43\ \ 5)$$
$$z = r[9.77119]\sin(v + 174\ \ 6\ 13)$$

NEW ASTRONOMICAL WORK.

Catalog der Astronomischen Gesellschaft. Erste Abtheilung. Elftes Stuck. Zone +15° bis +20°, *beobachtet auf der Sternwarte Berlin.* pp. (161) 367. A. AUWERS.

The northern section of the *Catalog der Astronomische Gesellschaft* is to consist of fifteen parts. Eight of these have now been published, and a ninth (Cambridge, Eng.,) is in press. The present volume contains the observed positions in the first Berlin zone of 9789 stars. This volume, prepared by Dr. AUWERS from his own observations, contains not only the catalogue of star-places, but also very much more, amounting, in fact, to a complete compilation of available knowledge relating to meridian observations of stars within the zone +14° 50′ to +20° 10′. The methods by which systematic unity in the observed positions, and in their relation to the *Fundamental-Catalog*, was secured are presented in minute detail; there are extensive tables exhibiting the individual results of a comparison of this catalogue with every other star-catalogue of any importance, and there are extensive discussions of the systematic differences; finally, the discussion of proper motion is exhaustive. In the appendix is contained a catalogue of 1300 stars in this zone, for which proper motion has been determined; and in another place are given the details of the computation for this purpose in relation to 1035 stars. In the introduction is printed a list of 97 stars in this zone having proper motion, in each instance, of $0''.25$ or more. Of these, 51 are there derived for the first time; and of these new ones, that of $1''.893$ for Catal. No. 4999, and that of $1''.180$ for No. 6369, are remarkable; especially since the magnitude of each of these stars is only $9^M.2$. Dr. AUWERS finds that the average centennial proper motion for the stars arranged in order of magnitude can be very approximately expressed by the formula, $m\mu_0$, in which m is the magnitude; and $m\mu_0 = 33''.2$ is a constant. A better representation is had from the formula $\log m\mu = 1.5000 + 0.0200\,(m - 5.0)$. This attributes the following mean proper motions for a century to stars of the respective orders of magnitude.

M	″	M	″
1.0	26.3	6.0	5.52
2.0	13.77	7.0	4.95
3.0	9.61	8.0	4.54
4.0	7.55	9.0	4.22
5.0	6.32	10.0	3.98

Dr. AUWERS finds that his investigations point to a constant of precession that cannot differ much from that of BESSEL (which he adopts in proper-motion investigation), a result which is in substantial agreement with other recent investigations.

TISSERAND AND GYLDÉN.

It is with grief that we record the decease of these two prominent masters in Celestial Mechanics.

FRANCOIS FELIX TISSERAND, Director of the Observatory of Paris, died in that city 1896 Oct. 20, in the fifty-second year of his age. He was a native of Nuits-Saint-Georges, in the Côte d'Or.

J. A. HUGO GYLDÉN, Director of the Observatory of Stockholm, died there 1896 Nov. 10. He was born at Helsingfors in 1841, and has been for many years President of the *Astronomische Gesellschaft.*

Both these distinguished astronomers have contributed largely to the development of the Theory of Perturbations, and have essentially influenced its recent progress,—the one by his clear and orderly presentation of its present condition, the other by his new and very ingenious methods of treating it.

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NEW ASTRONOMICAL WORK.
TISSERAND AND GYLDÉN.

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BENJAMIN APTHORP GOULD.

It becomes the sad duty of the *Astronomical Journal* to announce the death of its founder. Suddenly, but painlessly, he passed away, in the evening hours of Thanksgiving Day, November 26. Thus closes a career of single-minded devotion to science, full of activity to the end. Our grief at the irreparable loss is tempered with gladness that he had the satisfaction of pursuing his work to the last, in the plenitude of his powers, and of leaving his final great undertaking — the reduction of his photographic measures of southern stellar clusters — in a condition substantially complete; so that it will be given to the world as it came from his hand. That he might be spared to do this was his most earnest solicitude and hope.

Benjamin Apthorp Gould was born in Boston, September 27, 1824. He entered the Boston Latin School in 1836, and graduated from Harvard College, with high distinction in classical, as well as in mathematical and physical studies, in 1844. After teaching for a year in the Latin School, he decided to devote himself to a purely scientific career. As a preparation for this, he went to Europe in July, 1845, to study astronomy, working at the Greenwich Observatory three months, at the Paris Observatory four months, at the Berlin Observatory a year, at Altona Observatory four months, and at Gotha Observatory one month. He returned home in 1848. In 1852 he was appointed to take charge of the longitude-determinations of the Coast Survey. He organized, developed and extended this service, retiring in 1867. Meanwhile, in 1855, he became Director of the Dudley Observatory in Albany, equipped and organized the institution, and carried it on without remuneration and at his private expense. He left it in 1859, after a severe struggle to preserve the institution for purposes of scientific investigation.

In 1859 he published his discussion of the places and proper motions of circumpolar stars, for use as standards in the Coast Survey. These, as revised by him in 1861, together with his similar list of clock-stars, were adopted as the standards for the American Ephemeris, and, as to the circumpolars, remain in such use to this day. In 1866 he published his reduction of D'Agelet's observations. About the same time he performed a similar service for the greater part of the observations made at the United States Naval Observatory since its establishment, and also for the expedition to Chili to determine the solar parallax. In 1866 he planned and executed the work of establishing, by the Atlantic cable, the relation in longitude between European and American stations. As actuary of the United States Sanitary Commission he conducted, and published in a large volume, extensive and important researches upon Military and Anthropological Statistics and the Distribution of Population. About the same time he undertook the reduction of Rutherfurd's photographs of the *Pleiades*. The results, partially published in 1866, were submitted completely, in an elaborate memoir, to the National Academy in 1870, together with a second memoir on the *Praesepe*. He was, indeed, a pioneer in the utilization of photography for exact astronomical measurement. About 1864 he built an observatory in Cambridge, equipped with an 8-ft. transit-instrument, and, until 1867, carried on a determination of the right-ascensions of all the stars to the tenth magnitude within one degree of the pole. This work was completely reduced, but the discussion and publication were postponed by his removal to Cordoba.

In 1865 he became intensely impressed with a desire to explore the southern celestial hemisphere. The opportunity to do so soon came. This project assumed at first the form of a private astronomical expedition, for which his friends in Boston had promised the pecuniary means; but, under the enthusiastic support of

Mr. Sarmiento, at first as Argentine Minister to this country, and later as President of that Republic, it rapidly broadened, and finally led to the establishment by Dr. Gould of a permanent National Observatory at Cordoba. This marks an epoch in modern astronomy, the equalization of our knowledge of the two celestial hemispheres. The institution and its work form an impressive monument to his memory.

It is impossible, in brief space, to describe or characterize the marvelous work here undertaken and so faultlessly pushed to completion by Dr. Gould, during the fifteen years of self-imposed exile from his native land, with unfaltering devotion and energy, in the face of difficulty and domestic bereavement. The work on the uranography of the southern heavens was finished in 1874, and was published under the title of the *Uranometria Argentina*, which will remain a classic for all time. The zone-observations, of the stars between 23° and 80° south declination, which were the original and always the dominant object of the enterprise, were begun in 1872, substantially completed in 1877, and revised in 1882-83. This work was embodied in the Zone-Catalogues containing 73,160 stars, which appeared in 1884. Parallel with this, and almost overshadowing it in importance, was carried on the independent series of meridian-circle observations for the General Catalogue of 32,448 stars, completed in 1885. Dr. Gould, besides, left the manuscript of the remainder of his series of fifteen volumes, not then published — containing the observations and the annual catalogues, incorporated in the General Catalogue — complete to the minutest detail, ready for the printer. These have since appeared from time to time — the last volume, rounding out his work, reaching Cambridge but a few hours before his death.

Another part of the work for the Cordoba Observatory, planned by Dr. Gould as a fitting extension of it, was a *Durchmusterung* of the southern sky. For this, indeed, he had provided the instrumental means and trained the assistants, it being his purpose to be ready to begin it at any time in case of unforeseen delay or accident to the other work. On leaving Cordoba he confided it to the care of Dr. Thome and Mr. Tucker, who have since so worthily conducted it.

Dr. Gould also established, under the auspices of the Argentine Government, a Meteorological service, second in extent, it is believed, only to that of the United States. Upon leaving South America he intrusted this charge to the hands of his worthy successor, Walter G. Davis.

The earliest to recognize and demonstrate the capabilities of photography to render service to the astronomy of precision, Dr. Gould, by his experience with the Rutherfurd plates of the *Pleiades* and the *Praesepe*, was incited to arrange to carry forward at Cordoba, on an extensive scale, a similar work upon the southern stellar clusters. His other labors there were so onerous that he confined his attention to securing plates suitable for precise measurement. Of these he accumulated about 1400, and brought them home with him for measurement and reduction. Without permitting himself a well-earned retirement, he turned at once, tirelessly, to this labor, which has been the principal occupation of the last ten years of his life.

Dr. Gould had an enthusiasm for the advancement of his beloved science far wider than the limits of what he could by personal investigation accomplish. Early in his career he keenly realized that astronomy had reached a stage of development in America which entitled it to a higher claim than had yet been accorded to it; and that a journal worthily supporting the dignity of a pure science would have very great influence upon its future progress. Accordingly, without ostentation, he established the *Astronomical Journal* in November, 1849, offering it to the use of astronomers, for the publication exclusively of original investigations. He edited and supported it until, at the end of the sixth volume in 1861, its issue was suspended, first by the war for the preservation of the Union, afterward by his absence in Cordoba. A long nurtured hope was realized when he was enabled, in 1885, to resume its publication, and to continue it, at the rate of nearly one volume annually, to the present time. Of all the great enterprises of his life, this is the one which he has most cherished. With careful forethought, he has made due provision for its continuance.

Dr. Gould married, in 1861, Mary Apthorp Quincy, daughter of the Hon. Josiah Quincy. She died in 1883. Her sympathy with and influence upon his life-work may be most reverently spoken of by recalling the lines of his dedication of the Zone-Catalogue: —

"This Catalogue of Southern Stars, the fruit of nearly thirteen years of assiduous toil, is dedicated to the beloved and honored memory of Mary Apthorp Quincy Gould, to whose approval and unselfish encouragement the original undertaking was due, by whose sympathy, self-sacrifice, and practical assistance its execution was made possible, who bravely endured privation, exile, and afflictive bereavement that it might be worthily finished, but who has not seen its completion."

THE NOVEMBER LEONIDS, 1896,

BY EDWIN F. SAWYER.

While it was not expected that the Leonids would return this year in sufficient numbers to constitute a shower, it was, nevertheless, rather confidently expected that more than the average number recorded during the past twenty years would manifest themselves. The results obtained by the writer Nov. 11, 12 and 14, the 13th being unfortunately overcast until $17^h\ 30^m$, were, however, very meagre, and failed to reveal more than the ordinary number of stragglers recorded each year at the passage of the earth across the cometary-meteor orbit. The maximum (if the few tracks recorded can be construed as representing this phase) occurred on the morning of Nov. 15, but was at best but a very feeble manifestation of this well known meteor-shower's appearance.

The results obtained during each morning's watch were as follows: Nov. 11, watch from $13^h\ 30^m$ to $14^h\ 10^m$; very clear, three meteors recorded, none conformable to the Leonid radiant. Nov. 12, watch from $13^h\ 20^m$ to $14^h\ 20^m$; hazy in east during 20^m of the time, obscuring stars fainter than the 4th magnitude; very clear afterwards; four meteors seen, one being a Leonid. Nov. 13, watch from $17^h\ 30^m$ to $17^h\ 45^m$; cloudy and stormy until time of watch, then partially hazy and twilight, obscuring stars fainter than the 3d magnitude; not a meteor observed. Nov. 14, watch from $13^h\ 55^m$ to $15^h\ 10^m$; very clear, eleven meteors recorded, six of these being undoubtedly Leonids, representing a very feeble return of the shower.

From six paths quite accurately recorded on the 12th and 14th, one being nearly stationary, the radiant point was fairly determined as at R.A. 148°+20°. The majority of the unconformable tracks mapped came from the direction of *Gemini*.

METEOR TRACKS MAPPED.

No.	Date	Boston M.T.	Mag.	Observed Path From R.A.	Observed Path From Decl.	Observed Path To R.A.	Observed Path To Decl.	Length of Path	Wt.	Remarks
		h m		°	°	°	°	°		
1	Nov. 11	13 57	4	123	+22	127	+22	4	3	
2	11	14 5	4	139	+37	142	+34	4	3	
3	12	13 50	2	152	+32	156	+42	10	3	Leonid
4	14	13 56	2	155	+21	156	+21	1	4	Nearly stationary; streak 2 sec.
5	14	13 57	3	166	+21½	172	+22½	5	4	From δ *Leonis;* Leonid
6	14	14 25	4	169	+22½	175	+25	6	4	Leonid ?
7	14	14 26	4	146	+29	147½	+26	3	4	
8	14	14 35	3	166	+25	170	+26	4	3	Leonid
9	14	14 45	4	118	+21	126	+20	8	3	
10	14	14 58	4	133	+8	130	+6	4	3	Leonid; between ε and ζ *Hydra*
11	14	15 5	1	194	+17½	203	+15	10	3	Leonid; 1 sec.

Center of observation each night, Leo. View restricted to one-sixth of the visible heavens.

Brighton, 1896 *Nov.* 17.

MICROMETRICAL MEASURES OF F. 70 *OPHIUCHI*,

MADE AT THE OBSERVATORY OF THE UNIVERSITY OF MINNESOTA,

BY F. P. LEAVENWORTH.

The following measures were made with the 10½-inch refractor, and magnifying power of 300. The last three observations were taken in full daylight. There was no flaring as at night, and the images were round and well defined.

Date of Observation	Position Angle	Distance
	°	″
1896.529	289.7	2.22
1896.765	288.0	2.20
1896.768	288.1	2.21
.787	288.9	2.20
.790	288.2	2.15
1896.822	288.6	2.15
1896.741	288.6	2.19

OBSERVATIONS OF THE LEONID METEORS OF 1896,

MADE AT THE WASHBURN OBSERVATORY,

BY G. C. COMSTOCK AND A. S. FLINT.

During the morning hours of November 13 and 14 (astronomical reckoning) the constellation Leo and the adjacent parts of the heavens were carefully watched to determine the presence or absence of any meteor showers which might be connected with the great Leonid display, recurring at intervals of thirty-three years. Although clouds interfered seriously with the observations of both nights, the following memoranda of the observers indicate a well marked shower of Leonids on Nov. 13, and very feeble traces of such a shower on Nov. 14. No attempt at determining the radiant point of the shower was made, since this can, presumably, be much better done by the aid of photography than by eye estimates of meteor paths. The known position of the Leonid radiant was, however, used as a criterion for adopting or rejecting as Leonids the meteors actually seen.

Friday, Nov. 13.7, 1896, A. S. Flint, *Observer.* The sky was overcast at $11\frac{1}{2}^h$, but had cleared at $14\frac{1}{2}^h$. Began watching for meteors at $15^h 40^m$, keeping the Sickle, in the constellation Leo, as the center of attention. By $16^h 14^m$, or in an interval of 34 minutes, 18 meteors were seen, of which 15 were directed from the Leonid radiant, while 3 had paths widely different from that direction. At $16^h 10^m$ *Jupiter* and *Regulus* were disappearing behind thickening clouds from the west, and at $16^h 14^m$ the sky was overcast.

At $17^h 17^m$ the sky was clear again, and the watch was resumed and continued until the twilight became pretty bright. In 26 minutes, by $17^h 43^m$, 12 meteors were seen, all directed from the Sickle. Several were bright, equal to stars of the first to the third magnitude.

During both watches all grades of brightness were represented, several meteors being very faint flashes. All the bright ones had trains, which were of very short duration, not more than two seconds. The trains appeared of a light rosy color, in one or two instances greenish. All were very swift.

Saturday, Nov. 14.7, G. C. Comstock, *Observer.* Moonlight and clouds prevented observations up to $15^h 30^m$, about which time the sky became almost perfectly clear. Between $15^h 40^m$ and $16^h 40^m$ six meteors were counted in the area within 25° of the Sickle in Leo, two of which were certainly not Leonids, one was of doubtful origin, and three were probably Leonids. All of the latter were faint, swift, and of short path and very feeble train. Between $16^h 40^m$ and 17^h my attention was diverted to other observations, but within the ten minutes following $17^h 0^m$ two Leonids were seen, one of which was very brilliant, brighter than first magnitude, and had a train about 20° in length. The watch for meteors was discontinued at this time.

Madison, Wis., 1896 *Nov.* 16.

ELEMENTS AND EPHEMERIS OF COMET *f* 1896 (*PERRINE*),

By W. J. HUSSEY and C. D. PERRINE.

From Mt. Hamilton observations of Nov. 2, 3 and 4, we have computed the following elements and ephemeris of Comet *f* 1896.

$$\begin{array}{rl} T = & 1897 \text{ Jan. } 18.6072 \text{ Gr. M.T.} \\ \varphi = & 133^\circ\ 8'\ 35'' \\ \Omega = & 78\ 33\ 48 \\ i = & 145\ 52\ 56 \\ \log q = & 0.18868 \end{array} \left.\begin{array}{l} \\ \\ \\ \\ \\ \end{array}\right. \begin{array}{l} \\ \\ 1896.0 \\ \\ \\ \end{array}$$

Residuals for the middle place,

$$\text{O}-\text{C}, \quad \Delta\lambda \cos\beta = -5'' \; , \; \Delta\beta = +1''.$$

Mt. Hamilton, Cal., 1896 *Nov.* 5.

Constants for the equator,

$$\begin{aligned} x &= r[9.92185] \sin(v+146^\circ\ 52'\ 29'') \\ y &= r[9.98846] \sin(v+245\ \ 43\ \ \ 5\ ) \\ z &= r[9.77449] \sin(v+174\ \ \ 6\ \ 43\ ) \end{aligned}$$

Ephemeris for Greenwich Midnight.

	App. α	App. δ	Br.	log Δ
	h m s	° ′ ″		
1896 Nov. 6.5	20 15 16	22 6 11	0.96	0.198
10.5	20 9 43	19 7 15		0.215
14.5	20 5 17	16 24 23		0.232
18.5	20 1 48	13 56 41	0.83	0.249

The brightness at discovery, Nov. 2, is taken as unity.

ELEMENTS AND EPHEMERIS OF COMET *f* 1896 (*PERRINE*),*

By F. H. SEARES.

The following elements and ephemeris of Comet *f* 1896 (Perrine) have been computed by Mr. R. T. Crawford and myself, from observations made at the Lick Observatory by Mr. Perrine, on Nov. 2, 3 and 4. The observations were sent by telegraph to the Students' Observatory by Dr. Holden.

$$\begin{array}{rl} T = & 1897 \text{ Jan. } 23.6384 \text{ Gr. M.T.} \\ i = & 145^\circ\ 55'\ 22'' \\ \Omega = & 79\ 52\ 47 \\ \omega = & 138\ 59\ 40 \\ \log q = & 0.172302 \end{array} \begin{array}{l} \\ \\ \text{Mean Equinox 1896.0} \\ \\ \\ \end{array}$$

Middle place O – C: $\Delta\lambda \cos\beta = -3''.7 \; , \; \Delta\beta = +0''.9.$

Ephemeris for Greenwich Mean Midnight.

	α	δ	log ρ	Br.
	h m s	° ′		
Nov. 11.5	20 8 29	+18 23.3	0.219	0.92
15.5	20 4 17	15 42.8	0.235	0.88
19.5	20 0 56	13 16.7	0.251	0.84
23.5	19 58 19	+11 4.0	0.267	0.81

The brightness on Nov. 2 is taken as unity.

Students' Observatory, University of California, 1896 *Nov.* 13.

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* The telegraphed values were given in a Supplement to no. 388.

DISCOVERY OF THE COMPANION TO *PROCYON*,

By J. M. SCHAEBERLE.

This morning I discovered a companion to *Procyon*, of about the thirteenth magnitude, in position-angle 318°.8, distance 4″.59.

My two sets of measures are as follows:

Telesc. W. of pier; *Procyon* E. of merid., $P = 319^\circ.66$, $\Delta = 4''.58$ } Wt. 2

Telesc. E. of pier; *Procyon* W. of merid., $P = 317^\circ.20$, $\Delta = 4''.60$ } Wt. 1

It is quite probable that the observed perturbations of *Procyon*, ascribed by Bessel to a theoretical companion, are caused by this newly discovered star, as the position-angle of Prof. Auwers's theoretical perturbing body is about 275°.

The companion is yellowish in color, and sharply defined; assuming it to be the perturbing body, its mass is about one-fifth of the mass of *Procyon*.

Lick Observatory, 1896 *Nov.* 14.

OBSERVATIONS OF MINOR PLANETS AND COMETS,

MADE AT THE VASSAR COLLEGE OBSERVATORY,

By Prof. MARY W. WHITNEY and CAROLINE E. FURNESS.

Greenwich M.T.	*	No. Comp.	Object — *		Apparent		log *p*		Obs.
			Δα	Δδ	α	δ	for α	for δ	
			Chaldaea (313).						
1895 h m s			m s	′ ″	h m s	° ′ ″			
Sept. 21 15 29 15	1	10	+0 13.27	+ 0 40.7	1 36 10.24	+ 3 58 55.5	*n*9.494	0.741	F
22 15 31 44	2	9	+1 6.95	− 2 58.7	1 35 34.73	+ 3 49 17.5	*n*9.480	0.742	F
24 15 17 20	3	12	+0 45.84	− 5 59.5	1 34 20.32	+ 3 29 48.7	*n*9.491	0.745	F
28 15 34 27	4	7	+0 25.93	− 6 41.2	1 31 35.58	+ 2 49 9.2	*n*9.409	0.747	F
Oct. 8 16 9 48	5	1	−2 9.77	− 3 46.1	1 23 39.12	+ 1 3 39.5	*n*9.055	0.758	F
Nov. 6 15 32 10	6	10, 8	−1 54.60	+ 3 50.5	1 0 29.65	− 3 13 59.6	8.890	0.793	F
			Andromache (175).						
Nov. 21 16 15 47	7	5	−2 59.37	+ 1 21.4	4 50 13.94	+25 40 23.8	*n*9.258	0.417	W
27 22 1 10	8	7	−0 34.25	−12 42.0	4 44 41.01	+25 35 35.0	9.668	0.644	W
			Amalthea (113).						
Dec. 16 15 29 23	9	5	+0 17.82	− 9 35.3	5 29 12.51	+17 53 49.9	*n*9.164	0.561	W
16 15 49 1	9	8	+0 16.96	− 9 31.6	5 29 11.65	+17 53 53.6	*n*9.030	0.555	F
17 15 15 55	9	6	−0 48.56	− 8 55.9	5 28 6.15	+17 54 29.3	*n*9.209	0.564	W
18 13 51 6	9	7	−1 51.27	− 7 57.4	5 27 3.45	+17 55 27.8	*n*9.479	0.604	F
			Ismene (190).						
1896 Jan. 16 14 42 20	10	7	−0 0.72	− 4 30.5	7 14 25.94	+14 20 23.3	*n*9.298	0.613	T*
16 15 23 45	10	10	−0 2.14	− 4 24.9	7 14 24.52	+14 20 28.9	*n*9.085	0.612	F
			Niobe (71).						
Feb. 2 15 28 18	11	11	+1 15.73	+ 0 48.9	8 32 8.67	+24 50 42.4	*n*9.153	0.424	F
			Hermione (121).						
Mar. 5 15 48 53	12	8	−0 6.05	− 0 44.5	10 30 25.25	+20 2 34.3	*n*8.907	0.613	W
7 15 29 8	13	4	+1 34.56	+ 3 13.6	10 29 4.10	+20 9 8.4	*n*9.009	0.514	F
9 15 24 15	13	9	+0 13.96	+ 9 19.2	10 27 43.51	+20 15 14.1	*n*8.970	0.510	F
			Electra (130).						
Apr. 15 15 17 36	14	9	+1 23.23	+ 4 47.1	13 41 38.63	+16 41 13.7	*n*9.291	0.590	F
16 14 13 8	14	10	+0 43.54	+ 9 57.3	13 40 58.95	+16 46 24.0	*n*9.473	0.617	F
			Svea (329).						
Apr. 16 14 55 43	15	10	−1 37.11	− 3 54.4	13 8 34.15	+ 3 42 10.7	*n*9.207	0.736	F
			Comet *b* 1896.						
May 15 15 27 39	16	9	+1 29.48	+ 9 24.8	1 21 56.23	+68 12 28.9	*n*9.389	0.913	F
16 15 19 39	17	8	+0 19.76	+ 1 7.2	1 14 43.94	+68 42 34.6	*n*9.426	0.911	W
			Comet *f* 1896.						
Nov. 7 13 1 9	18	8	+1 1.64	+ 1 6.4	20 13 38.59	+21 16 8.1	9.530	0.577	W

* Mary Tarbox, Student.

November 7. Comet very faint.

Mean Places of Comparison-Stars for Beginning of the Year.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 35 53.31	+3.66	+ 3 57 48.4	+26.4	Boss, Albany A.G. Catal. 473
2	1 34 24.10	+3.68	+ 3 51 49.7	+26.5	" " " " 465
3	1 33 30.76	+3.72	+ 3 35 21.6	+26.6	" " " " 460
4	1 31 5.86	+3.79	+ 2 55 23.4	+27.0	Micr. comp. with Boss, Albany A.G. Catal. 444
5	1 25 45.06	+3.83	+ 1 6 58.4	+27.2	Boss, Albany A.G. Catal. 417
6	1 2 20.23	+4.02	− 3 18 15.8	+25.7	Micr. comp. with Schj. 379
7	4 53 8.27	+5.04	+25 38 46.8	+15.6	Weisse's Bessel IV, 1142
8	4 45 10.14	+5.12	+25 48 0.3	+16.7	" " " 958
9	5 28 19.48	+5.23	+18 3 13.5	+11.7	Vienna Zones, 1860
10	7 14 24.53	+2.13	+14 24 50.5	+ 3.3	Weisse's Bessel VII, 357
11	8 30 50.42	+2.52	+24 49 49.9	+ 3.6	Becker, Berlin A.G. Catal. 3447
12	10 30 28.66	+2.61	+20 3 29.3	−10.5	" " " " 4062
13	10 27 26.88	+2.66	+20 6 4.3	− 9.5	" " " " 4048
14	13 40 12.67	+2.73	+16 36 44.6	−18.0	Weisse's Bessel XIII, 800
15	13 10 8.65	+2.61	+ 3 46 22.8	−17.7	Boss, Albany A.G. Catal. 4671
16	1 20 28.53	−1.78	+68 3 4.7	− 0.6	Fearnley, Christiania A.G. Catal. 269
17	1 14 26.00	−1.82	+68 41 28.6	− 1.2	" " " " 250
18	20 13 34.67	+2.28	+21 14 44.0	+17.7	Becker, Berlin A.G. Catal. 7608

ELEMENTS AND EPHEMERIS OF COMET *f* 1896 (PERRINE),

By C. D. PERRINE.

The following elements are derived from my observations of November 2, 6 and 11.

$$T = 1897 \text{ Feb. } 8.15286$$

$$\left.\begin{aligned} \omega &= 172^\circ\, 37'\, 36'' \\ \Omega &= 86\;\; 28\;\;\; 0 \\ i &= 116\;\;\; 8\;\; 42 \end{aligned}\right\} 1896.0$$

$$\log q = 0.024318$$

Residuals for middle place (O−C),

$$d\lambda \cos\beta = -4''.0 \quad ; \quad d\beta = -1''.0$$

CONSTANTS FOR THE EQUATOR OF 1896.0.

$$x = r[9.91969] \sin(176^\circ\, 52'\, 44'' + v)$$
$$y = r[9.97966] \sin(278\;\; 58\;\; 47 + v)$$
$$z = r[9.80026] \sin(211\;\; 37\;\;\; 6 + v)$$

The elements involving the time of perihelion passage and distance must be considered as somewhat uncertain yet.

Lick Observatory, 1896 *Nov.* 16.

The time of my observation of Nov. 3, as *telegraphed*, is slightly in error, owing to an error of mine in converting to the decimal of a day.

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1896	App. α	App. δ	log r	log Δ	Br.
	h m s	° ′			
Nov. 23.5	19 57 20	+10 26.1	0.2092	0.2424	1.00
25.5	56 6	9 17.8			
27.5	55 1	8 12.2	0.1970	0.2543	1.00
29.5	54 3	7 8.9			
Dec. 1.5	53 11	6 8.0	0.1847	0.2655	1.00
3.5	52 26	5 9.3			
5.5	51 46	4 12.8	0.1722	0.2760	0.99
7.5	51 12	3 18.2			
9.5	50 42	2 25.4	0.1596	0.2856	0.98
11.5	50 16	1 34.4			
13.5	19 49 54	+ 0 44.9	0.1470	0.2941	0.96

The brightness at discovery is taken as unity.

OBSERVATIONS OF COMET *b* 1896 (SWIFT),

MADE AT THE DUDLEY OBSERVATORY, ALBANY,

By ARTHUR J. ROY.

1896 Albany M.T.		*	No. Comp.	☄ − *		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
June 5	10 7 34	13	10	−0 23.68	+2 3.2	22 55 8.08	+72 50 16.4	n0.118	0.660
10	10 21 38	15	8	−0 11.87	−2 29.7	22 22 32.41	+72 45 27.3	n0.159	0.459

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
13	22 55 31.97	−0.21	+72 48 23.7	−10.5	Anon 12ᴹ. From comparison with * 14
14	22 59 7.92	. .	+72 47 58.1	. .	Argelander's Northern Zones 25078
15	22 23 13.65	+0.63	+72 48 7.9	−10.9	Anon 10ᴹ.5. From comparison with * 16
16	22 22 29.65	. .	+72 53 16.6	. .	Argelander's Northern Zones 24105

$\Delta\alpha$ measured micrometrically. Very faint.

FINDING EPHEMERIS OF COMET *c* 1896 (1889 V),

(Continued from *Astronomical Journal*, no. 386),

By CHARLES LANE POOR.

Greenw. M.T.	App. α	App. δ	log Δ
	h m s	° ′ ″	
1896 Dec. 2.5	23 2 38.8	−6 39 54	0.22060
4.5	5 42.4	−6 13 30	
6.5	8 48.8	−5 46 54	0.23200
8.5	11 58.3	−5 20 6	
10.5	15 10.1	−4 53 5	0.24330
12.5	18 25.0	−4 25 53	
14.5	21 41.9	−3 58 33	0.25446
16.5	25 1.0	−3 31 3	
18.5	28 22.6	−3 3 24	0.26546
20.5	31 46.2	−2 35 40	
22.5	35 11.4	−2 7 45	0.27631
24.5	38 38.4	−1 39 47	
26.5	42 7.6	−1 11 41	0.28701
28.5	45 38.3	−0 43 31	
30.5	49 10.5	−0 15 20	0.29751
1897 Jan. 1.5	23 52 44.6	+0 12 58	
1897 Jan. 3.5	23 56 20.1	+0 41 21	0.30790
5.5	23 59 57.1	+1 9 46	
7.5	0 3 35.4	+1 38 12	0.31809
9.5	7 15.0	+2 6 38	
11.5	10 55.9	+2 35 0	0.32809
13.5	14 37.9	+3 3 24	
15.5	18 20.6	+3 31 48	0.33789
17.5	0 21 55.7	+4 0 6	

At the time of the last published observation in September the corrections to the above ephemeris were extremely small. Although the comet is very faint, I hope that many observations will be obtained, and that the results will be published as soon as possible after the series is finished.

OBSERVATIONS OF COMET *f* 1896,

MADE AT THE LICK OBSERVATORY WITH THE 12-INCH EQUATORIAL,

By C. D. PERRINE.

1896 Mt. Hamilton M.T.	*	No. Comp.	☄ − *		☄'s apparent		log pΔ	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Nov. 5 8 4 56	4	*d*10 , 8	−0 23.62	−1 45.2	20 16 33.37	+22 44 57.4	9.540	0.468
6 8 26 4	5	*d*10 , 8	+0 35.08	+2 48.7	20 14 56.47	+21 56 23.1	9.585	0.511
11 7 40 24	6	*d*10 , 9	+0 24.38	+6 0.2	20 8 5.27	+18 9 51.0	9.543	0.548
12 8 1 54	7	*d*10 , 8	+0 1.87	+1 30.9	20 6 52.79	+17 25 54.3	9.585	0.579
13 9 47 59	9	*d*10 , 9	−0 5.09	−6 33.0	20 5 40.48	+16 40 18.5	9.683	0.676

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
4	20 16 54.71	+2.28	+22 46 24.0	+18.6	Becker, Berlin A.G. Catal. 7656
5	20 14 19.11	+2.28	+21 53 16.3	+18.1	Becker, Berlin A.G. Catal. 7631
6	20 7 38.59	+2.30	+18 3 34.8	+16.0	Auwers, Berlin A.G. Catal. 8019
7	20 6 48.62	+2.30	+17 24 7.7	+15.7	Micrometer-comparison with *8
8	20 9 23.39	+2.31	+17 29 0.9	+16.0	Auwers, Berlin A.G. Catal. 8014
9	20 5 43.28	+2.29	+16 46 36.3	+15.2	Micrometer-comparison with *10
10	20 5 34.81	+2.29	+16 50 28.4	+15.2	Auwers, Berlin A.G. Catal. 7987

d. $\Delta\alpha$ measured directly with the micrometer.

THE NOVEMBER LEONIDS OF 1896,

By E. E. BARNARD.

Preparations were made to observe the Leonids, but a cloudy sky limited the time of observation to about an hour in the morning. At 16^h the clouds began breaking, and by $16^h 20^m$ the sky was very clear, and so remained for nearly one hour, after which it again clouded up, with only the brighter stars visible.

From $16^h 20^m$ to $17^h 15^m$, eighteen meteors were seen; fifteen of these were Leonids. Two of these were of the first magnitude. With two or three exceptions, the others were of the fifth and sixth magnitude. The bright ones were very white, and left rather persistent trains of a greenish white. The radiant was well marked. At the close of the observations, an imaginary circle three or four degrees in diameter was drawn on the sky, the center of which was estimated to have been the radiant. Taking this point from the chart it gave,

$$\text{Radiant} \quad \alpha_0 = 150° \quad , \quad \delta = 27°.$$

Charting seven of the observed paths the apparent radiant was found to be at

$$\alpha_0 = 149°.5 \quad , \quad \delta = +27°.$$

The intersections all fell within a circle about 2° in diameter. The radiant was therefore close to the above position.

In a table of meteor-radiants in the new edition of *Webb's Celestial Objects*, Vol. I, Mr. Denning gives the radiant for the Leonids as

$$\alpha_0 = 150° \quad , \quad \delta = +22° \quad , \quad \text{at } \gamma \, \textit{Leonis}.$$

The radiant was certainly 5° north of this point in the observations of the present year.

Williams Bay, 1896 *Nov.* 14.

OBSERVATIONS OF COMET *f* 1896 (*PERRINE*),

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 26-INCH EQUATORIAL,

By Prof. STIMSON J. BROWN.

[Communicated by Prof. Wm. Harkness, U.S.N., Astronomical Director.]

1896 Washington M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			m s	′ ″	h m s	° ′ ″		
Nov. 6 8h 37.6m	1	4 , 8	+0 2.78	−0 18.75	20 15 7.65	+22 1 56.8	9.5941	0.5494
9 8 0.4	2	4 , 8	−0 13.89	+5 33.35	20 10 47.89	+19 45 21.8	9.5537	0.5580

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	20 15 7.76	+2.28	+22 11 43.3	+18.3	Becker, Berlin A.G. Catal. 7637
2	20 10 59.48	+2.30	+19 39 31.4	+17.05	Auwers, Berlin A.G. Catal. 8063

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ON THE SOLAR MOTION AS A GAUGE OF STELLAR DISTANCES,

By SIMON NEWCOMB.

First Paper.

In making some studies preparatory to a redetermination of the precessional constant, I have been led to results so suggestive of the possibility of important inferences from a new method of treating the proper motions of the stars, that an exposition of the case seems of interest. In determining the constant of precession, two inherent sources of doubt and embarrassment are found in the facts that the proper motions of the stars are not distributed in magnitude according to the the normal law of error, and that the effect of the parallactic motion cannot be completely separated from the proper motion peculiar to each star. In Ludwig Struve's very thorough investigation of the precession, the distances of the stars are assumed to be, in the general mean, a function of the magnitude, those of each order of magnitude being distant nearly one-half farther than those of the preceding order. This hypothesis seems very doubtful, especially in view of Stumpe's recent investigation of the solar motion, which seems to show that this motion, measured in angular distance as seen from the stars, differs but little for stars of different orders of magnitude. If accepted to its fullest extent, the conclusion would be that, in the general mean, the stars of the different magnitudes have nearly the same parallax. Although this conclusion cannot be accepted, Stumpe's work makes it seem very likely that the differences in the mean parallax of bright and faint stars may be less than is commonly supposed.

Under these circumstances I set out to make a classification of the proper motions in declination of the stars contained in Auwers-Bradley, arranged in four groups, according to the magnitude of the star. The individual proper motions in declination for each group, contained between given equi-distant limits, were enumerated. The result is shown in the following table:

The first column gives the limits of the centennial proper motion within which the count was made. These limits comprise each second of arc from −15″ to +12″. All proper motions outside these limits were grouped together in the count.

The second column gives the number of proper motions contained between these limits for stars ranging from magnitude 1 to magnitude 3.4, which form Group I. I have accepted the magnitudes given in the original catalogue, as no material change will be made by seeking for the latest photometric result in the case of each star.

The next three columns give the corresponding quantities for Groups II, III and IV. It will be seen that the limits of magnitude for the several groups are as follows:—

Group I, Mag. 1 to 3.4
" II, " 3.5 to 4.9
" III, " 5.0 to 5.9
" IV, " 6.0 and over

The next column contains the sum for all four groups, and therefore shows, in the case of the stars of Bradley's catalogue, the number of proper motions in declination contained between each pair of limits given in the first column.*

Table Showing the Distribution of Auwers's Centennial Proper Motions in Declination, According to Magnitude, with Probable Distributions According to the Normal Law of Error.

Limits	Actual Distribution					Probable Distribution			
	Group I 1^m to $3^m.4$	Group II $3^m.5$ to $4^m.9$	Group III 5^m to $5^m.9$	Group IV $6^m.0$ +	Total	p.e. = ±2″.53 No.	Excess	p.e. = ±1″.50 No.	Excess
−∞″ and −15″	24	52	50	49	175	0	175	0	175
−15 " −14	3	2	3	7	15	0	15	0	15
−14 " −13	3	1	8	9	21	1	20	0	21
−13 " −12	1	2	4	12	19	2	17	0	19

---

* I remark that the sum total of proper motions exceeds the number of stars in the catalogue by 9. This seems to have arisen from my enumerator having made the error of counting separately the two values given by Auwers for the proper motions of stars near the pole.

Limits	Actual Distribution					Probable Distribution			
	Group I 1^m to $3^m.4$	Group II $3^m.5$ to $4^m.9$	Group III 5^m to $5^m.9$	Group IV $6^m.0$ +	Total	p.e. = ±2″.53		p.e. = ±1″.50	
						No.	Excess	No.	Excess
−12″ and −11″	2	4	6	9	21	5	16	0	21
−11 " −10	4	8	11	16	39	11	28	0	39
−10 " − 9	2	6	7	25	40	21	19	0	40
− 9 " − 8	4	6	12	21	43	36	7	0	43
− 8 " − 7	6	9	20	16	51	62	−11	2	49
− 7 " − 6	6	13	32	34	85	98	−13	11	74
− 6 " − 5	4	14	26	54	98	143	−45	32	66
− 5 " − 4	3	21	35	72	131	197	−66	80	51
− 4 " − 3	19	32	60	129	240	251	−11	158	82
− 3 " − 2	15	35	79	147	276	299	−23	257	19
− 2 " − 1	16	50	107	184	357	332	25	344	13
− 1 " 0	22	71	121	211	425	342	83	377	48
0 " + 1	21	30	98	192	341	330	11	341	0
+ 1 " + 2	19	30	72	158	279	297	− 18	249	30
+ 2 " + 3	12	32	51	92	187	248	−61	153	34
+ 3 " + 4	8	22	29	48	107	193	−86	75	32
+ 4 " + 5	3	16	19	32	70	140	−70	31	39
+ 5 " + 6	5	4	17	20	46	94	−48	11	35
+ 6 " + 7	2	1	9	14	26	62	−36	2	24
+ 7 " + 8	2	6	3	11	22	35	−13	0	22
+ 8 " + 9	1	6	4	10	21	19	2	0	21
+ 9 " +10	2	0	8	3	13	9	4	0	13
+10 " +11	0	2	4	5	11	4	7	0	11
+11 " +12	0	2	4	1	7	2	5	0	7
+12 " ∞	12	18	20	15	65	1	64	0	65
Sums	221	495	919	1596	3231	3234		2123	1108

By laying down the several equi-distant values of the proper motions as abscissa we may, by the aid of these numbers, construct a curve, showing the law of distribution of the numbers in magnitude. This curve deviates from the normal curve of error in several important features, each of which admits of a physical explanation. To understand these features we must consider the elements which determine the curve. We have in the proper motions as given and enumerated, firstly the effect of the probable error in the determination itself. In view of the fact that, in the case of each individual star, we have both the error of the Bradley determination, and the modern error combined, the conclusion seems unavoidable that the probable error may be a considerable fraction of a second. In the next place we have dispersion produced by the different effects of the solar motion in different parts of the sphere and at different distances. From the usually accepted value of this quantity, especially that found by Struve for stars of the sixth magnitude, it would seem that the range of the dispersion thus produced must, in the case of at least half the stars, amount to 2″. We have in the third place the actual proper motions of the stars themselves. The numbers of the table are made up of the combined effect of these three causes of dispersion. To make the features clear I give two columns of probable normal distribution, assuming that the dispersion should follow the normal law of error. In the first of these columns a probable error or dispersion from all causes amounting to 2″.53 is assumed, and the dispersion of the actual number of stars is given in the adjoining column. Comparing this with the actual numbers, it will be seen that the latter are greatly in excess, both at the central point and the two extremes. A comparison of the numbers of ordinates through the table shows the following features: —

I. The central point of the table, or the limits which contain the greatest number of proper motions, are not at the zero of proper motion, but between 0″.0 and −1″.0. The maximum seems to occur about −0″.5. This is readily accounted for by the effect of the solar motion.

II. The second feature is the rapid falling off in the numbers on each side of the maximum point. The conclusion indicated by this feature of the curve will be shown presently.

III. The third feature is the asymmetry of the curve. The numbers do not fall off with equal rapidity on each side of the central point, but with much more rapidity on the positive than on the negative side. This is especially seen in the respective numbers which surpass the two limits to which the count was extended. Although this limit, on the negative side, is 2″ farther from the central or maximum point than on the positive side, there are 175 proper motions outside of it, against 65 outside of the positive limit. Moreover, the asymmetry commences almost from the center of the curve.

The explanation is to be found in the unequal distances of the stars, and the consequent unequal effect of the solar motion upon their proper motions. Assuming that, in the general mean, the actual proper motions are equally distributed in the positive and negative direction, then, by grouping together equal numbers of stars having the largest negative and the largest positive motions; an equal number having the next largest negative and the next largest positive motions, etc., we may assume that the mean values of these quantities show the effect of the solar motion upon the several groups, which will be proportional to the mean parallax of the stars of each pair of groups.

We now return to the second feature of the curve, which expresses a curious bunching of the proper motions between the limits 0″.0 and −1″.0. This bunching is shown in each of the columns "Excess." In the first column there is an excess of 83 proper motions within these limits against 11 and 25 for the limits on each side. In consequence of this I have made a second table, showing the hypothetical distribution of 2,123 quantities with a probable error ±1″.5. We now have an excess of 48 proper motions between the central limits against only 13 between the adjoining limits on the negative side and no excess at all in the adjoining number on the positive side. Indeed, we cannot represent the central portion of the curve except by supposing a probable error of about 1″. But this is scarcely greater than the combined effect of the differences of parallactic motion in different parts of the hemisphere and the probable errors of the determination.

Unless this is a result of chance accumulation, it would indicate that there are a large number of stars, perhaps one-third of the whole, which have no appreciable proper motion except that due to the motion of the Sun. But I shall defer this subject until my next paper, which will contain a more complete investigation of this feature.

Let us now examine the conclusions to be drawn from the features already mentioned. It will be well to begin with a clear statement of the hypotheses on which we proceed. These hypotheses are not to be accepted as absolute truths, but as more or less probable approximations to the truth, to be tested by the consistency of the results to which they lead, and by their agreement with observation, and to be modified, if necessary. They are as follows:

I. That if we consider two great classes of stars A and B, scattered through the celestial spaces, the center of gravity of the two classes will, in the general mean, be at rest relatively to each other. When the two classes are distinguished only by the apparent magnitude of the individual stars composing them, this hypothesis seems a safe one.

II. That in any two such classes the mean scattering or dispersion of the absolute proper motions will be equal. We may take as the measure of the dispersion the square root of the sum of the squares of all the proper motions of the stars of each class. But there are other such measures which may be yet better, because the influence of extraordinarily large proper motions might be too great when this measure was adopted. We might take the limits within which $\frac{1}{2}$, $\frac{2}{3}$, or any other fraction of the proper motions are found to be contained as the measure of the dispersion.

There is a possibility that, in the general mean, the absolute proper motions of stars of one order are systematically different from those of another order. This, however, does not seem likely.

III. That the proper motions are as likely to be in one direction as in another. This hypothesis follows almost necessarily from the first.

Let us now consider the stars of our several classes, I–IV. In the case of each class the mean apparent proper motion of all the stars in the class in any one absolute direction in space will be due to the solar motion. Hence, it will be proportional to the mean parallax of all the stars of the class. The dispersion will also be in the same proportion. Thus we may obtain two independent though rather rude estimates of the ratio of the mean parallaxes of the separate classes.

By hypothesis I, the mean apparent proper motion of each group must be the mean parallactic motion. The theory of probabilities shows that in a case like the present, where there is a large deviation from the normal law of error, the mean values should be determined mainly from the quantities near the center or mean of the series. A difficulty arises in the present case from the asymmetry of the curve on the two sides of the center, which I have already described and explained. But any error thus arising will affect all the results in about the same proportion, so that the successive ratios will be but slightly altered, whether we take one set of limits or another. I have therefore taken means between those positive and negative limits where, by the probable error indicated by the central parts of the curve, the number of proper motions should be much smaller than that actually found. For these limits I have taken

Group I, −15″ to +11″ (counting all without these limits as if on them)
" II, −12 to +10 only
" III, −10 to + 8 "
" IV, − 8 to + 7 "

A more rigorous mode of proceeding would have been to assign a graduated series of weights, converging to zero at the two limits. The effect of this course would have been to slightly increase the negative values of the quantities, but their relative values, with which alone we are concerned, would not have been materially changed. The mean proper motions thus found for the four groups are as follows:

		(a)	(b)		
Group	I,	$\mu = -2''.45$	$-3''.05$	$S(\frac{5}{6}) = 26''$	$S(\frac{3}{4}) = 17''.0$
"	II,	-1.10	-1.70	20	12.6
"	III,	-1.01	-1.61	14	10.6
"	IV,	-0.77	-1.37	11.5	8.2

Column *a* gives the means of the proper motions as actually found; column *b* as corrected, with the approximate mean correction necessary to reduce the proper motions in declination of the A.G.C. to a new system which I have recently constructed. The mean amount of this correction is about $-0''.60$.

We next investigate the amount of dispersion of the proper motions. I have made two estimates of this by finding the difference of the limits, in the case of each group, which will contain $\frac{5}{6}$ and $\frac{3}{4}$ of the proper motions respectively. The results are those given above as $S(\frac{5}{6})$ and $S(\frac{3}{4})$.

Taking the parallax of Group III as unity, we have the following three sets of values of the relative mean parallax, of which the first is derived from the proper motions, the second from the limits which contain $\frac{5}{6}$ of the stars, and the third from the limits which contain $\frac{3}{4}$ of the stars. To these results I have given the respective weights 4, 2 and 1. The logarithms of the reciprocals of these numbers are next given, and after each the magnitude which would probably correspond to the mean of all the stars of the group. It will be seen that the progression of the logarithms is as good as we could expect, and indicates for each unit in the change of magnitude an increase of distance in the ratio whose logarithm is 0.081, or, say 1.20.

$\Pi_1 \div \Pi_3 =$	1.91	1.86	1.61	Mean = 1.85	Log = 0.267	Mag. = 2.7
$\Pi_2 \div \Pi_3 =$	1.06	1.43	1.19	1.18	0.072	4.4
$\Pi_3 \div \Pi_3 =$	1.00	1.00	1.00	1.00	0.000	5.5
$\Pi_4 \div \Pi_3 =$	0.95	0.96	0.77	0.87	-0.060	6.5

The general conclusion which we draw from the preceding investigation is that the effect of the solar motion diminishes less rapidly with the stars of fainter magnitude than has been supposed. Of this there is independent confirmation from two sources. In papers in the *Astronomical Journal*, Volume IX, Professor Boss has shown that the parallactic motion is quite appreciable in the stars of Lalande and of the Argelander zones. Quite recently I have unexpectedly stumbled upon a confirmation of this view, which practically illustrates the precision of the results which we may obtain from the rigorous modern method of planning and reducing observations of the stars. In continuance of the investigation upon the relation between the magnitude of the star and the personal equation of the observer who notes its right-ascension, I have had to make a comparison between the two Berlin zones observed by Auwers and by Becker.* These zones have in common 230 stars of magnitude 8.0 and upwards, lying close to the parallel of +20° declination, which forms the boundary between the zones. The mean difference, B−A, was taken for each octant, the octants being chosen so that their middle points fell upon 0^h, 3^h, etc., of R.A. The results were as follows:

R.A.	No. of Stars	B − A $\Delta\alpha$	$\Delta\delta$
0^h	24	$-0^s.006$	$-1''.10$
3	15	+ .023	−0.49
6	44	+ .009	−0.55
9	30	− .029	−0.76
12	13	− .051	−0.78
15	27	− .045	−0.91
18	43	− .014	−0.77
21	34	−0.005	−1.10

As both zones were reduced with the positions of the A.G.C. the periodic difference shown by the right-ascension was perplexing, until I observed that Becker's observations were made ten years later than Auwers's, and that the periodic term might be explained by the parallactic motion during the interval. The difference in right-ascension is expressible in the form,

$$\Delta\alpha\,(B-A) \;=\; -0^s.015 + 0^s.027\cos\alpha + 0^s.014\sin\alpha,$$

which shows a solar motion toward a point in the celestial sphere of which the right-ascension is very nearly

$$A \;=\; 297°,$$

and a centennial amount, as seen from the mean sphere of stars of the ninth magnitude, of $4''.6$.

The constant term $-0^s.015$ of the difference is about what we should expect from the error of Struve's Precessional Constant, but is no greater than what might be the effect of personal equation between the observers.

The declinations give

$$\Delta\delta\,(B-A) \;=\; -0''.81 \;-0^s.06\cos\alpha \;+0''.19\sin\alpha.$$

The constant term $0''.81$ is not readily explained. It would indicate a centennial parallactic motion in declination amounting to $8''.1$, which is far out of the question. Moreover, the periodic terms in declination have the opposite sign from that of the parallactic motion. They are, however, uncertain by their entire amount.

I hope soon, in a second paper, to treat the subject more fully by a modified method.

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* I had worked out the results of this easy comparison, before noticing that Auwers had made a similar comparison in the Introduction to his Catalogue.

ON DIFFERENTIAL REFRACTION FOR PHOTOGRAPHIC MEASURES,

(REPLY TO MR. HAROLD JACOBY),

BY H. H. TURNER.

It is really rather difficult to know how to deal with Mr. HAROLD JACOBY. He has produced a set of erroneous differential refraction formulas, the errors in which have been patiently and repeatedly pointed out by Mr. DYSON, and yet Mr. JACOBY seems quite unable to see them. Under ordinary circumstances one might be content to let him go his own way, hoping that time or some accident might reveal to him what a plain statement apparently cannot. But unfortunately he has been placed by Dr. GILL in a position of some importance, having been invited by him to collect and criticize the formulas for reduction of photographic measures on stellar plates (*Bull. du Com. Perm.*, Tome III). This work in the hands of a competent person would have been most valuable; in those of one capable of making and maintaining a mathematical blunder it is worse than useless. We all of us make mistakes at times, but we can generally be made to see them. I don't know whether I shall below put the matter more plainly than Mr. DYSON has done for Mr. JACOBY; but I hope it will be clear enough to warn others against putting faith in his remarks or criticisms. This may sound severe; but the harm that may be done by an incompetent mathematician is so great as to require plain speaking.

In the *Monthly Notices* for 1893 November, page 14, I give the following formulas for differential refraction. (I quote from this page to avoid a small side-issue.)

$$\begin{aligned} d\xi &= \beta_0 \{(1+X^2)\,\xi + XY\eta\} \\ d\eta &= \beta_0 \{XY\ .\ \ \xi + (1+Y^2)\,\eta\} \end{aligned}$$

where X, Y, are the coordinates of the zenith, supposed projected through the center of the object-glass on to the plate. Mr. JACOBY advances the formulas

$$\begin{aligned} d\xi &= k'\xi\,\{(1+X^2) - Y\cot P\} + k'\eta\,\{XY - X\cot P\} \\ d\eta &= k'\xi\,\{XY + X\cot P\} + k'\eta\,\{1+Y^2\} \end{aligned}$$

where P is the North Polar Distance of the center of the plate.

Now, there is one conspicuous difference between these sets of formulas, viz: that Mr. JACOBY's formulas involve the pole, while mine do not. He has got various terms multiplied by cot P, which involves the N.P.D. of the center of the plate. Here then is a vital question: Has the pole any business in the formulas, or not? I am aware that many eminent astronomers find a difficulty in making abstraction of the pole and the earth's rotation; but really, we have no concern with them in a photograph. Suppose the earth did *not* rotate, would the photograph be different? Suppose it rotated about quite a different pole (and the zenith-distance of the plate remained the same, of course), would the photograph be in any way different? The edges of the plate might run in different directions, but the aspect of the stars would be just the same.

If there is any doubt on this point, we may suppose the exposure *instantaneous*, in which case the rotation has no effect whatever: and though exposures in practice are seldom instantaneous, they are in most cases treated as though they were taken instantaneously at the middle of the exposure.

The pole has no business in our differential refraction formulas. It is a sort of King Charles's Head to some astronomers, but in photographic work it must be kept out of the manuscript, or it will do mischief. Here, for instance, is Mr. JACOBY, proposing formulas for differential refraction which become infinite at the pole! Let me beg him to examine a photograph of the pole, and see whether there is any infinite disturbance. He will find that the disturbance due to refraction is precisely similar to that on a plate taken on the south side of the zenith at an equal zenith distance. His formulas would give infinitely different results in the two cases; the correct formulas give the same results, as they should.

This being the nature of the mistake made, it seems extraordinary that it can have been maintained at all. But it becomes less surprising when we study Mr. JACOBY's controversial methods. I subjoin three examples of these methods, one from each of his papers, which will, perhaps, be sufficient.

(*a*). In his first paper, *A.J.*, no. 350, p. 108, he says: "Formulas for M_x, etc., have been also given by Prof. TURNER (*M.N.*, *R.A.S.*, LIV, p. 18), and while he has deduced them in an ingenious way, he has omitted a necessary step, and his results are incorrect."

It will scarcely be believed that no attempt is, or has since been made, to point out the "necessary step omitted." Mr. JACOBY should realize that such accusations should not be made unless the maker is prepared to support them by direct evidence.

(*b*). In his second paper, *A.J.*, no. 366, p. 43, he says: "I think no one will question that these values of α and p are the apparent coordinates of the star . . . . . , and I here explicitly assume that such is the case."

In a mathematical investigation assumption of this kind is entirely out of place. The thing either is so, or is not so, and whether any man or woman questions it is quite an irrelevant matter. A man who can introduce a paragraph of this kind into a mathematical investigation does not understand the principles of mathematics. This fatal habit of assumption vitiates the whole of this paper. In the second paragraph of it he says: "If we compute α and p

by means of the above formulas directly from the measured coordinates ξ and η, we shall get the *apparent* α and p of the star." This is a pure assumption, and absolutely wrong. We cannot get the *apparent* α and p of a star from measurements of a photograph by any formulas whatever which do not involve the hour-angle. Consider, for instance, a star actually at the pole, raised by refraction some distance above it. Its apparent R.A. changes uniformly from 0^h to 24^h. How is this to be got from formulas independent of the time.

(*e*). In his third paper, *A.J.*, no. 387, Mr. Jacoby writes: "I must object to Mr. Dyson's statement on the top of the second column of p. 102 in no. 373 of the *Journal.* He says that I have given two contradictory statements in nos. 350 and 354 of the *Journal.* I am unable to find these contradictory statements in any of my articles, nor have I published any article at all in no. 354 of the *Journal.*"

Now to make capital out of a mere slip of the pen seems an unworthy device. Mr. Jacoby's two articles are in Nos. 350 and 366, and Mr. Dyson's in no. 354. The three numbers were doubtless before the latter in writing, and by a slip of the pen 350 and 354 were substituted for 350 and 366. Surely, Mr. Jacoby must have seen this. It is not as if the papers on this subject had been so numerous; the present note only makes six, though it is certainly six too many. But I will not imitate Mr. Jacoby by assuming anything. I will take his own words: "I am unable to find these contradictory statements in any of my articles." What, then, are the statements? Mr. Dyson's words, "on the top of the second column of p. 102 in *A.J.*, 373," are as follows: * * * "is the difference between $d\{(\alpha-A)\sin P\}$ given by Prof. Jacoby in *A.J.*, 354, as equal to $d\xi$, and $\sin P\, d(\alpha-A)$ which he previously gave as equal to $d\xi$ in *A.J.*, 350."

As Prof. Jacoby cannot find these "in any of his articles," will he kindly turn to *A.J.*, 366 (which as above stated was miswritten 354), page 13, the 9th line of the first column, where we read

$$d\xi = d[(\alpha-A)\sin P]$$

and now, please, to *A.J.*, 350, page 109, column 1, lines 6 and 7, where we read, "we must add to $X\sec\delta$, the corrections $M_xX\sec\delta + N_xY$," in which I *hope* he will be able to identify the other statement; though it looks as if he did not understand his own formulas, for he actually proceeds to correct them in his next paragraph by a term $kG\tan\delta\sin 1''$, which is equivalent to the difference between $d\{(\alpha-A)\sin P\}$ and $\sin P d(\alpha-A)$.

The papers of Mr. Jacoby are full of such instances of wrongness and unfairness, but I think enough has been said.

OBSERVATIONS OF THE COMPANION OF *SIRIUS*,

MADE WITH THE 26-INCH TELESCOPE OF THE U.S. NAVAL OBSERVATORY,

By Prof. STIMSON J. BROWN.

[Communicated by Prof. Wm. Harkness, U.S.N., Astronomical Director.]

In the spring of the present year, every clear evening from March 8 to March 25, systematic search was made for the companion of *Sirius.* The observations were confined to the few minutes of good seeing which occur here just after sunset, and when the star was most favorably situated near the meridian.

On three occasions, I observed an object which I could see distinctly for very brief intervals, but which was so entangled in the brilliant rays of *Sirius*, that its position could be measured only with great difficulty. I did not consider, at the time, that observations made under such circumstances, and with so much uncertainty in the measured distance, would justify the announcement of a rediscovery of the satellite which had been last observed with the more powerful Lick-objective at a distance only a little smaller.

Since the publication in the *Journal* of the observations of Dr. See at the Lowell Observatory, and the later ones of the Lick Observatory, showing such unaccountable differences in the position of the companion, I have felt that my observations might prove of importance. They are accordingly given below, just as recorded in the observing book.

"March 13, 1896. *Sirius.*

Position-Circle	Micr. Readings	
95°.16		power 600 (?)
100.30	64.577	
93.20	63.715	
96.22	0.862	
parallel 86.12	$s = 4''.29$	
$p =$ 190.10		

"Seeing not good; but at times image steady — at such times I saw persistently an unsteady, faint object just within the edge of the dancing rays. Started to measure but seeing became worse. Haven't much confidence until this is verified."

"March 14, 1896. *Sirius.*

"Seeing not very good — get an image similar to the one seen last night but in position-angle

C. R. 94°.50	Micr. readings 64.75
parallel 86.02	64.75
$p =$ 188.48	64.68
	64.73
	Coincidence 64.20
	$s = 0.53 = 5''.27$

"Evidently not the same object, and illusory."

"March 21. *Sirius.*

"Using positive 600 and 900 magnifying power — latter too high. Get the same appearance as on the 14th.

Position-circle 95°.4, $p = 189°.4$; $s = 5''.00$ (estimated).

"I think it is a spurious object, although get the same object with the negative eyepiece. Magnifying power, 520."

Washington, D.C., 1896 *Dec.* 1.

NEW ELLIPTIC ELEMENTS AND EPHEMERIS OF COMET *d* 1896 (GIACOBINI),

BY WILLIAM J. HUSSEY.

From normal places for Sept. 8.5 and Oct. 3.5, and the mean of my two observations of Oct. 29, I have computed new elliptic elements of this comet. The data were as follows:

Greenw. M.T.		α	δ
		h m s	° ′ ″
1896 Sept.	8.5	17 18 28.03	− 8 9 57.6
Oct.	3.5	18 17 44.92	−11 48 15.3
	29.65763	19 36 56.79	−13 44 19.8

The first normal place is based on 26 European and American observations from Sept. 5 to Sept. 11, inclusive; the second normal place is based on 19 Mt. Hamilton observations from Sept. 28 to Oct. 8, inclusive. These include practically all of the published observations. The observations of Oct. 29 were made with the 36-inch telescope, $\Delta\alpha$ and $\Delta\delta$ being both measured directly with the micrometer. The above places are corrected for parallax and aberration, and are referred to the mean equinox of 1896.0.

The elements are as follows:

Epoch 1896 Sept. 5.5 Greenw. M.T.

$$M = 354° 28' 7''.88$$

$$\left.\begin{aligned} \omega &= 139\ 29\ \ 6\ .34 \\ \Omega &= 192\ \ 5\ 36\ .82 \\ i &= 11\ 32\ 42\ .25 \end{aligned}\right\} 1896.0$$

$$\varphi = 41\ \ 6\ 29\ .13$$

$$\log e = 9.8178836$$

$$\log a = 0.6360428$$

$$\log \mu = 2.5959424$$

Period 3286 days = 9.00 years.

Residuals for the data are

	O−C		
$\Delta\alpha$ =	+0ˢ.01	0ˢ.00	0ˢ.00
$\Delta\delta$ =	+0″.2	+0″.2	−0″.1

CONSTANTS FOR THE EQUATOR, (1896.0).

$$x = r[9.9996178]\sin(v + 61° 20' 27''.47)$$

$$y = r[9.9901669]\sin(v + 330\ 49\ 24\ .35)$$

$$z = r[9.3315231]\sin(v + 342\ 21\ 19\ .29)$$

EPHEMERIS.

Gr. M.T.		True α	True δ	Δ	Aberr.	Br.
		h m s	° ′ ″		m s	
Nov.	24.5	21 2 40.77	−12 44 48.9	0.1811	12 36	0.23
	26.5	9 17.70	32 57.0			
	28.5	15 53.19	20 7.8	0.1900	12 51	0.22
	30.5	22 27.06	−12 6 23.4			
Dec.	2.5	28 59.13	−11 51 46.0	0.1992	13 8	0.21
	4.5	35 29.22	36 17.7			
	6.5	41 57.15	20 0.7	0.2086	13 25	0.20
	8.5	48 22.74	−11 2 57.1			
	10.5	21 54 45.79	−10 45 9.1	0.2183	13 43	0.18

Brightness for September 8.5 = 1.

NOTE. The epoch for the second system of elements in *Astronomical Journal* no. 387 should have been 1896 Sept. 0.0 Gr. M.T.

Mt. Hamilton, Cal., 1896 *Nov.* 24.

OBSERVATIONS OF COMETS,

MADE AT THE LAWS OBSERVATORY OF THE STATE UNIVERSITY OF MISSOURI,

BY MILTON UPDEGRAFF.

1896 Columbia M.T.		*	No. Comp.	☄ − *		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
				COMET *a* 1896.					
	h m s			m s	′ ″	h m s	° ′ ″		
Mar. 8	10 3 24	1	5	+0 47.68	− 0 43.0	2 27 39.5	+50 20.2	9.849	0.660
10	7 51 10	2	3	+0 12.13	+ 4 36.6	2 46 37.03	+49 27 18.3	9.808	0.151
11	7 56 47	3	10	−1 40.65	− 0 22.7	2 55 3.64	+48 58 55.3	9.805	0.172
12	8 6 38	4	10	−3 7.40	− 6 8.7	3 2 41.09	+48 29 14.1	9.806	0.222
16	7 55 57	5	11	−2 7.24	+ 4 29.7	3 26 32.65	+46 49 24.7	9.775	0.165
19	9 33 13	6	6	+2 40.10	− 4 37.2	3 40 3.65	+45 41 53.5	9.817	0.551
20	8 11 59	7	8	−3 31.56	− 5 26.2	3 43 38.26	+45 23 12.7	9.777	0.280
				COMET *c* 1895.					
Mar. 19	16 27 15	8	5	+0 37.52	− 4 22.5	19 43.1	+ 7 19	*n*9.553	0.693
				COMET *b* 1896.					
May 5	8 45 8	9	3	+1 47.0	+10 9.1	2 31 23.9	+59 48 21.4	9.787	0.858

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	2 26 52.2	−0.12	+50 20.6	+16.6	Bonn DM. 50°, 579
2	2 46 25.12	−0.22	+49 22 24.6	+17.1	Deichmüller, Bonn A.G. Catal. 2457
3	2 56 44.42	−0.13	+48 59 0.7	+17.3	" " " " 2574
4	3 5 48.54	−0.05	+48 37 5.4	+17.4	" " " " 2683
5	3 28 39.77	+0.12	+46 44 37.9	+17.1	" " " " 3023
6	3 37 23.38	+0.17	+45 46 11.1	+16.6	" " " " 3125
7	3 47 9.56	+0.26	+45 28 22.3	+16.6	" " " " 3244
8	19 42.5	+0.51	+ 7 23	−14.7	
9	2 29 37.95	−1.05	+59 38 5.7	+ 6.6	Krueger, Helsingfors A.G. Catal. 2370

The observation of Mar. 10 was interrupted by clouds, and that of May 5 was interrupted by the comet going out of sight behind a tree. Both are poor. Comet *c* 1895 was found to be too faint for accurate observation with a telescope of this aperture, 7½ inches.

OBSERVATIONS OF COMET *b* 1896, (*SWIFT*),

MADE AT THE OBSERVATORY OF THE UNIVERSITY OF MINNESOTA.

[Communicated by F. P. Leavenworth.]

1896 Minneapolis M.T.	*	No. Comp.	☄ − *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
May 6 10 22 33	1	4 , 3	−0 51.04	+0 56.5	2 24 35.23	+61 4 44.5	9.346	0.915
8 11 16 42	2	8 , 4	−4 13.43	+5 1.8	2 10 59.93	+63 12 40.7	*n*8.778	0.922
11 16 42	3	8 , 4	−5 19.42	+8 50.9	2 10 59.69	+63 12 41.8	*n*8.778	0.922
18 11 19 36	4	8 , 4	+3 25.79	−7 56.3	0 59 33.07	+69 38 43.1	9.807	0.851
11 19 36	5	8 , 0	+0 59.64	. .	0 59 32.73	. . .	9.807	. .
30 12 7 9	6	3 , 4	−3 39.58	−0 37.0	. . .	. . .	. .	. .

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	2 25 27.44	−1.17	+61 3 41.8	+6.2	Kreuger, Helsingsfors-Gotha A.G. Catal. 2311
2	2 15 14.73	−1.37	+63 7 33.9	+5.0	" " " " " 2169
3	2 16 20.47	−1.36	+63 3 45.8	+5.1	" " " " " 2192
4	0 56 9.14	−1.86	+69 45 42.3	−2.9	Fearnley, Christiania A.G. Catal. 199
5	0 58 35.03	−1.86	+69 45 41.5	−2.7	" " " " 205

The observations were made with the 10½-inch equatorial and filar micrometer. The position of the observatory is long. $6^h\ 12^m\ 56^s.90$ west from Greenwich, lat. 44° 58′ 39″.5. The observations of May 6 and 18 were made by A. F. Maxwell and H. Garrity, students in the observatory. Those of May 8 and 30, by F. P. Leavenworth. On May 30 the comet was very faint and difficult.

NEW COMET.

A new comet has been discovered by Perrine. Position, 1896 Dec. 8.8540 Gr. $\alpha = 0^h\ 52^m\ 26^s.7$, $\delta = +6°\ 24'\ 52''$. Daily motion $+4^m\ 20^s$, southward 30′; well defined nucleus, and tail; 8^M.

NOTICE.

With the assent of the family, it has been decided to place, in the title-heading of each number, and upon the title-page of each volume, the words "Founded by B. A. Gould," as a permanent memorial. — Ed.

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On the Solar Motion as a Gauge of Stellar Distances, by Prof. Simon Newcomb.
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Observations of Comets, by Prof. Milton Updegraff.
Observations of Comet *b* 1896 (Swift), by Prof. F. P. Leavenworth.
New Comet.
Notice.

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COMPARISON OF STANDARD STAR-PLACES WITH OBSERVATION,

By R. H. TUCKER.

The meridian-circle observations of Standard Stars, made at this Observatory, will be published with full details. In the meantime there are some results that can be given in definitive form, and which appear to be of interest in their bearing upon the relation of Standard Star Systems.

The present series embraces all stars down to −40° declination, given in the American Ephemeris, *Connaissance des Temps*, and British Nautical Almanac; and which are not in the list of the *Berliner Jahrbuch*. The additional stars, introduced in the N.A. list for 1897, are included.

The observed places, being based upon B.J. stars as fundamental, a comparison of these places with the various ephemerides may be considered as in a measure supplementing the comparison made by Dr. Auwers, printed in B.J., 1884, which embraced all stars common to B.J. and any one of the others.

For this comparison there are available 66 stars from A.E., 86 from C.T. and 41 from N.A.; in general, about one-third as many as are included in the comparison by Dr. Auwers.

The consideration of the system of Fundamental Stars is first in order. A list of 86 stars, between −10° and +15° declination, has been observed as fundamental. A few stars lie just outside these limits.

Ephemeris-Comparison of Fundamental List.

	s	s	″	″		
B.J.−A.E.	−0.027	(±0.002)	+0.01	(±0.03)	for 51	stars
B.J.−C.T.	+0.015	(±0.005)	−0.24	(±0.06)	" 53	"
B.J.−N.A.	+0.022	(±0.002)	+0.19	(±0.03)	" 56	"

The above are for the mean declination +2°.

B.J.−303 $+0^s.001$ ($\pm 0^s.002$) $-0''.51$ ($\pm 0''.03$) for 50 stars, at the mean declination −2°.4, for the list published in the B.J. appendix.

These differences have been applied in obtaining the columns of residuals in Table I. But, as the declinations of circumpolar stars, observed at both culminations, are independent of the general systematic error of the Fundamental List, no residuals have been taken out for those stars in declination. For convenience both the direct difference (Obs.−Eph.) and the mean of the differences where each has been divided by sec δ have been given for the circumpolar right-ascensions. This causes a reversal of sign in the case of the C.T. group.

The values given in the table result from combining the stars in groups of 5° of declination. All comparisons are included, with the exception of those noted at the foot of the table.

Each star has been given 4 observations in each position of the instrument, and the circumpolars have been given 4 at each culmination in each position. The reductions have been made without the use of proper motions; but for purposes of this comparison the ephemeris proper motions have been included.

Some further consideration of the relation between the observed places and the B.J. system will be appropriate. The agreement for the mean of the equatorial zone of Fundamental Stars is necessarily exact. These stars have been observed on the average 15 times each.

There are no further means of direct control, beyond the following: the deviation (Obs.−B.J.) $-0^s.026$ ($\pm 0^s.007$) $-0''.16$ ($\pm 0''.08$) for two groups, containing 16 stars near the zenith, observed for bisection-error; and the comparison with the B.J. places of circumpolar stars.

For the latter, there are observations of 45 B.J. stars, a few slightly below 70° declination having been included. These have been observed 21 times each, on the average. The observed declinations are in all respects independent of the B.J. places, except that B.J. proper motions have been included in the reductions. This will introduce no important correction, since in most cases the mean epoch of observation is not far from the epoch of reduction, 1895.0. The azimuth has been obtained by the use of B.J. right-ascensions; but since three stars have been observed at each culmination, every night, and the result combined with the indication of the mire reading, the observed right-ascensions are not greatly influenced so far as any one star is concerned.

The mean difference in right-ascension is (Obs. − B.J.) $-0^s.008 \sec\delta$.

This may be due to systematic error of observation for slow-moving stars. There is no difference between right-ascensions determined at upper and lower culminations; from which the inference is, that the observed correction to B.J. is not due to direction of motion, nor to instrumental corrections, unless these two balance. It may be an instance of personal equation in transit.

No adjustment in right-ascension has been made, and the residuals given in Table I are left to represent the comparison of the observations with the ephemerides, for stars not in B.J. The adjustment of the declination-differences for Table II will be described below.

I. Table Giving the Δ(Obs. − Eph.) for Every 5° of Declination.

A.E.						C.T.						N.A.					
δ	No.	ΔR.A.	v	Δδ	v	δ	No.	ΔR.A.	v	Δδ	v	δ	No.	ΔR.A.	v	Δδ	v
°		s	s	″	″	°		s	s	″	″	°		s	s	″	″
+87.1	3	−0.23	−0.20	−0.19	. .	+87.6	5	+0.54	+0.52	−0.05	. .	. . .		. . .	. . .	. .	. .
. . .	.	−0.021 sec δ	−0.019 sec δ	. .	. .	. . .		−0.004 sec δ	−0.004 sec δ	. .	. .	. . .		. . .	. . .	. .	. .
82.6	1	−0.83	−0.80	−0.77	. .	84.8	1	+0.27	+0.26	(1)	. .	. . .		. . .	. . .	. .	. .
.	.	−0.106 sec δ	−0.103 sec δ	. .	. .	. . .		+0.025 sec δ	+0.024 sec δ	. .	. .	. . .		. . .	. . .	. .	. .
75.7	3	−0.10	−0.07	+0.35	. .	. . .		. . .	. . .	. .	. .	. . .		. . .	. . .	. .	. .
. . .	.	−0.024 sec δ	−0.017 sec δ	. .	. .	. . .		. . .	. . .	. .	. .	. . .		. . .	. . .	. .	. .
73.1	3	−0.08	−0.05	+0.03	. .	. . .		. . .	. . .	. .	. .	. . .		. . .	. . .	. .	. .
. . .	.	−0.018 sec δ	−0.014 sec δ	. .	. .	. . .		. . .	. . .	. .	. .	. . .		. . .	. . .	. .	. .
68.0	5	−0.075	−0.048	−0.03	−0.04	. . .		. . .	. . .	. .	. .	. . .		. . .	. . .	. .	. .
. . .	.	. . .	. . .	. .	. .	54.1	1	−0.03	−0.05	−1.0	−0.8	. . .		. . .	. . .	. .	. .
41.8	2	−0.076	−0.049	−0.03	−0.04	40.2	2	+0.10	+0.08	−0.7	−0.5	. . .		. . .	. . .	. .	. .
36 2	1	−0.121	−0.094	+0 41	+0.40	38.3	4	−0.09	−0.11	−0.1	+0.1	. . .		. . .	. . .	. .	. .
32.9	2	−0.059	−0.032 (2)	−0.27	−0.28	32.5	3	−0.01	−0.03	−1.3	−1.1	. . .		. . .	. . .	. .	. .
26.9	3	−0.082	−0.055	+0.31	+0.30	28.2	2	−0 05	−0.07	−1.8	−1.6	+27.5	1	−0.044	−0.066	+0.38	+0.19
21.0	6	−0.038	−0.011	+0.15	+0.14	21.5	3	+0.01 (3)	−0.01	+0.1	+0.3	21.3	3	0.000	−0.022	+0.19	0.00
17.3	4	−0.024	+0.003 (4)	+0.27	+0.26	. . .		. . .	. . .	.	. .	19.7	1	−0.028	−0.050	+0.12	−0.07
12.4	3	−0.052	−0.025	−0.41	−0.42	11.4	2	−0.12	−0.14	−1.8	−1.6	12.8	2	+0 032	+0.010	+0.12	−0.07
7.1	4	−0.031	−0.007	+0.46	+0 45	6.6	5	+0.02	0.00	+1.2	+1.4	7.0	2	+0.061	+0.039 (5)	+0.02	−0 17
+ 2.5	6	−0.001	+0.026	−0.02	−0.03	+ 3.6	3	+0.25	+0.23	+0.3	+0.5	+ 3.9	3	+0.031	+0.009	+0.24	+0.05
. . .	.	. . .	. . .	. .	. .	− 3.1	2	+0.07	+0.05	+0.1	+0.3	. . .		. . .	. . .	. .	. .
− 7.8	7	−0.016	+0.011	−0.17	−0.18	− 7.1	7	+0.02	0.00	0.0	+0 2	. . .		. . .	. . .	. .	. .
−12.7	3	+0.020	+0.047	−0.02	−0.03	−12.5	4	−0.02	−0.04	−1.1	−0.9	. . .		. . .	. . .	. .	. .
−18.9	3	−0.008	+0.019	−0.42	−0.43	−18.0	9	0.00	−0.02	−0.9	−0.7	−17.0	2	+0.038	+0.016	+0.12	−0.07
−24.1	1	−0.001	+0 026	−0.22	−0.23	−23.2	3	+0.06	+0.04	−1.3	−1.1	−23.2	3	−0.003	−0.025	−0.42	−0.61
−26.3	4	+0.008	+0.035 (6)	+0.02	+0.01	−27 5	10	+0.06	+0.04	+0.1	+0.3	−27.3	10	+0.037	+0.015	−0.14	−0.33
−32.2	2	−0.051	−0.024	−0.02	−0.03	−33.1	11	+0.01	−0.01 (7)	−0.1	+0.1	−32.8	6	+0.015 (8)	−0.007	−0.61	−0.80
. . .		. .	. . .	. .	. .	−38.0	9	0.00	+0.02 (9)	−1.3	−1.1	−37.2	8	−0 003	−0.025	−1 38	−1.57

Comparisons omitted: (2) Δδ (−1″.4) (4) Δδ (+1″.6) (6) Δδ (−3″.2) (1) Δδ (+2″.1) (3) Δα (+0s.52) (7) Δδ (+3″.0) (7) Δδ (+3″.9) (9) Δδ (+3″.6) (5) Δδ (+1″.6) (8) Δα (+0s.22)

The following comparisons, including all stars observed, may have place here, as exhibiting the results from material more extensive than that given in Table I.

EPHEMERIS RIGHT-ASCENSIONS OF CIRCUMPOLAR STARS.

B.J. − A.E.	= $-0^s.008 \sec\delta$	for	30 stars
B.J. − C.T.	= $-0.030 \sec\delta$	"	12 "
B.J. − N.A.	= $+0.023 \sec\delta$	"	10 "

OBSERVED RIGHT-ASCENSIONS OF CIRCUMPOLAR STARS.

Obs. − B.J.	= $-0^s.008 \sec\delta$	for	45 stars
Obs. − A.E.	= $-0.018 \sec\delta$	"	40 "
Obs. − C.T.	= $-0.055 \sec\delta$	"	18 "
Obs. − N.A.	= $+0.002 \sec\delta$	"	10 "

The effect of magnitude upon transits (in relation to which a note was published in *A.J.*, 380), has been determined by means of more than 150 transits, half being reduced by screen, an average of 4.0 magnitudes below the normal brightness. The resulting difference, $-0^s.034$ ($\pm 0^s.002$), would indicate a correction of $-0^s.009$ per magnitude, to be applied to the observed right-ascensions of faint stars. But, in my opinion, a correction of this nature becomes effective only in extreme cases, through force of contrast, and probably is not sensible through small range of magnitude.

The mean magnitude of the fundamental list is 3.7, three-quarters of the stars being included between 3 and 5. A comparison of the observed correction to B.J. places of the equatorial stars, gives the following, omitting the only star brighter than 2, one abnormal difference of right-ascension, and that of *o Ceti*.

12 stars	2.3 mag.	(Obs. − B.J.) $+0^s.001$
32	3.3	+0.004
28	4.2	0.000
11	5.6	−0.020

This comparison gives indication of an effect contrary to that by screen, if the B.J. right-ascensions are assumed to be free from correction depending upon magnitude. The right-ascension of *o Ceti*, however, confirms the screen results, 11 observations, at an estimated brightness $8\frac{1}{2}$, giving (Obs. − B.J.) = $+0^s.059$.

In closing the right-ascension comparisons, there remains the statement of the mean accidental deviations of observation from the ephemerides, which are given without taking account of systematic differences.

	s			
B.J.	±0.024	sec δ	146	comparisons
A.E.	±0.040	sec δ	158	"
C.T.	±0.04	sec δ	157	"
N.A.	±0.028	sec δ	109	"
303	±0.016	sec δ	59	"

In declination the agreement of the observed places of circumpolar stars with B.J. is exact. And this, by chance, is true, whether all 45 stars observed be included, or only 32 stars, observed at both culminations, be counted. That exact agreement is casual, is evident from the fact that the observed place differs from B.J. by more than 0″.5 in six cases; so that the omission of a few stars from the observing list might have produced some small deviation.

The observations of the above 32 stars, and of 15 not in B.J., unite in giving the systematic difference,

$$\frac{\text{U.C.} - \text{L.C.}}{2} = +0''.10$$

This difference represents the observed error of the mean of the Fundamental List, *plus* twice the bisection-error of observation. Since the best value derived for bisection-error, as determined at the zenith, for the mean epoch of observation, almost precisely satisfies this difference, the virtual agreement of the observed places with B.J. at the pole and equator may be adopted.

It may be an open question whether the results of a determination, made at the zenith, can be assumed to be valid for increased zenith-distance. But, in the absence of other means by which an independent measure of such error can be made, they deserve consideration.

The present determination rests upon observations of pairs of stars, situated one each side the zenith, made facing north and south alternately, reversing the order on the succeeding night. A single determination of bisection-error consists of four observations, equivalent to one pair of stars on two nights. Some of these were made by observing a pair, or two pairs each night, in the regular course of work; others by taking four or five pairs on special nights. The same series furnish a measure of the error in transit, due to the direction of the star's motion.

Following are the results of all series observed for this purpose, tabulated in the sense, (S − N); $\frac{1}{2}\Delta\varphi$ being the observed bisection-error.

		$\Delta\alpha$	$\frac{1}{2}\Delta\varphi$
		s	″
1894.1	8 det.	−0.035	+0.13
1894.6	5	–	−0.03
1895.6	10	−0.020	+0.13
1896.4	8	−0.026	+0.03
1896.5	8	−0.035	−0.02

The difference in right-ascension is consistent throughout, and indicates a correction to the observed right-ascension of stars north of the zenith of $-0^s.029$; or $-0^s.023 \sec\delta$ if assumed to vary with secant of declination. For circumpolar stars, observed at both culminations, the effect would be eliminated; and there remain 13 stars of the list to which it may be applicable. One-half the correction should also be applied to the right-ascensions of the group of B.J. stars at the zenith, giving as a result (Obs. − B.J.) = $-0^s.040$.

For zenith-distances, the second series having been observed without transits, may have been influenced thereby, and should possibly be rejected. But the indications are strong that a bisection-error of approximately 0″.1 in the beginning of the present series of observations had virtually disappeared at the close. The best value of bisection-error to be derived from all the series is +0″.06.

In its application, circumpolar stars observed at both culminations will be independent of this error if it is conceded to be constant at all zenith-distances. The declinations of all stars south of the zenith will not be affected, upon the same assumption. For 13 stars of the list, between the zenith and 70° declination, the correction −0″.12 would be required, if this error be adopted; and the group of B.J. zenith-stars would similarly require one-half the double correction, or −0″.06, giving (Obs. − B.J.) −0″.22.

These corrections have not been applied. Since about two-thirds of the zenith-observations were made in combination with the equatorial zone of Fundamental Stars, that many have been available for the comparison (Obs. − B.J.).

The last previous determination of my bisection-error was made at Cordoba, from observed declinations of circumpolar stars at both culminations. The result 0″.00 was, however, based upon an invariable latitude. In reference to the apparent change in observing-habit, I have never permitted myself to be conscious of the direction in which such an error would operate in telescopic bisections, and have thus remained free from personal bias. But, possibly, the effect of the zenith-observations, with also the knowledge which early reductions could not fail to give of a difference in latitude between observations of polar stars and of B.J. equatorial stars, have served to direct attention especially towards this most important observing feature, with a consequent improvement in habit.

Such evidence emphasizes the utility of differential work, and tends to incline one strongly towards that as a final resource, once our standard star-systems have been brought to their highest perfection.

The comparison of the declinations of all circumpolar stars observed can close this portion of the discussion.

EPHEMERIS DECLINATIONS OF CIRCUMPOLAR STARS.

	″			
B.J. − A.E.	+0.06	for	30	stars
B.J. − C.T.	−0.1	"	12	"
B.J. − N.A.	−0.02	"	10	"

OBSERVED DECLINATIONS OF CIRCUMPOLAR STARS.

	″		
Obs. − B.J.	0.00	for 15	stars
Obs. − A.E.	+0.05	" 10	"
Obs. − C.T.	+0.1	" 18	"
Obs. − N.A.	+0.16	" 10	"

The two comparisons will evidently present some deviations, since the groups of stars differ.

The full comparison with the list of 303 stars affords a further approximate control upon the observed places in declination. For 50 stars, common to B.J. and 303, divided into 5° groups, there results:

COMPARISON WITH 303.

Decl.		(Obs. — 303)
°		″
+3.4	17 stars	−0.26
−2.6	17 "	−0.55
−8.4	16 "	−0.61

and for the stars observed, which are not in B.J.,

−15°	9 stars	−0″.77

The divergence is so nearly in accord with the known systematic difference of the two lists (+0″.50 −0″.02 δ°), that the inference is that the series of observations is an approximate extension of the present B.J. system southwards.

The accidental errors of the observed places may next be considered. The effect of division-error upon the observed declinations may be estimated from the completed measurement of the 1° arcs of the fixed circle used.

The probable error of graduation is found to be ±0″.15 for the mean of four divisions. In the absence of further investigation as to periodic character which is somewhat evident, it will be assumed that this error is not diminished by reading upon two adjoining divisions.

The probable errors of the observed places have been obtained by full comparison of determinations made circle east and circle west. No systematic differences have been adopted. As is to be expected, the results are, in general, larger than those obtained by a comparison of individual observations with the mean of four, in the same position, also fully completed. The results of the first comparison are accordingly given as representing the largest probable errors (accidental) to be expected for the mean of eight observations.

In right-ascension: p.e. = $\pm 0^s.010 \sec\delta$ up to 70° declination and $\pm 0^s.004 \sec\delta$ for the circumpolar stars observed at both culminations. The results, for stars of high declination, are decidedly smaller.

In declination: average p.e. = ±0″.14, ranging from ±0″.11 at the equator to ±0″.25 at the extremes, −40° declination and 70° L.C. Circumpolar stars ±0″.10. The p.e. of declinations can be very closely represented by the square root of the following expression:

$$(0''.10)^2 + (0''.04 + 0''.05 \,\Delta \tan \mathrm{Z.D.})^2,$$

where the last term of the second quantity depends upon the difference between the tan Z.D. of the star and the tan Z.D. of the equatorial zone of stars used as fundamental; and the p.e. due to graduation is represented by ±0″.10.

In general, I believe that accidental errors in declination have a similar form, and that abnormal differences and variations in refraction will affect observations according to a term depending upon the angular distance from the reference-point, aside from the increasing unsteadiness due to large zenith-distance. Differential determinations will reduce such a term as much as possible.

The mean accidental deviations in declination of all the observed places from the ephemerides, are as follows:

	″			
B.J.	±0.28	for 147	stars	1 Δ exceeds 1″
A.E.	±0.36	" 157	"	6 exceed 1″ 1 exceeds 3″ (omitted)
C.T.	±0.9	" 158	"	8 exceed 3″
N.A.	±0.41	" 109	"	9 exceed 1″ (1 omitted) 8 are south of −25°
303	±0.26	" 59	"	

In the case of 303, only, has any systematic difference been applied. The value 0″.5 was used as constant for that list, and there remain no residuals exceeding 0″.7.

Table II has been formed by an approximate adjustment of the declinations of Table I (Obs. − Eph.). The observed differences were combined in larger groups, of more nearly equal weights, furnishing salient points for a graphical representation. It is based entirely upon stars not in B.J., thus being supplementary to the comparison made by Dr. AUWERS.

As results of observation, the values will be subject to no change upon publication of the details.

II. TABLE OF ADJUSTED VALUES Δ (OBS. − EPH.) IN DECLINATION.

Decl.	A.E.	C.T.	N.A.
°	″	″	″
90	−0.02	0.0	. .
80	−0.01	−0.1	. .
70	+0.01	−0.3	. .
60	+0.03	−0.4	. .
50	+0.05	−0.5	. .
40	+0.07	−0.6	. .
30	+0.08	−0.5	+0.20
20	+0.10	−0.2	+0.18
10	+0.06	+0.1	+0.15
0	0.00	0.0	+0.13
−10	−0.06	−0.2	−0.11
−20	−0.12	−0.5	−0.35
−30	−0.18	−0.7	−0.58
−40	. .	−1.0	−0.81

If the evident divergence of the series of observations from the ephemerides were to be ascribed to refraction, there would be necessary a decrease in the Pulkova refraction-constant for this place.

To satisfy the declinations of the American Ephemeris at the pole and at −30° declination, this decrease would be but 0″.04; a small quantity, when it is also evident that an error of half a degree in the temperature recorded, or of one-twentieth of an inch in the barometer-reading, would more than compensate for the deviation. It may be that the circumstances of a high altitude, and, in general, very low humidity, produce refraction-effects slightly dissimilar to those allowed for by our present theory.

For the deviations from the *Connaissance des Temps* and Nautical Almanac, a decrease about four times as large would appear to be required, while for the list of 303 stars seven times the decrease necessary for A.E. is indicated. These quantities would amount respectively to 0″.1 for A.E., 0″.3 for C.T. and N.A., and 0″.5 for 303, if the divergence only from the equator southwards were to be compensated.

Flexure, to the amount of 0″.1 sin Z.D. has been applied to the final declinations. Resting upon a large number of determinations, under varied conditions, and distributed through three years, it would not appear possible that its amount should be increased sufficiently to account for the deviations that have been under discussion.

The present series of observations was undertaken at the request of Dr. E. S. Holden, who has given it cordial support.

The Fundamental List is the larger part of one selected by Dr. Auwers for a right-ascension system. In all, the places of 305 stars have been determined.

Lick Observatory, 1896 *Nov.* 18.

MEASURES OF THE BINARY SYSTEM OF 85 *PEGASI* (β 733),

By J. M. SCHAEBERLE.

The following measures of this binary star were made with the 36-inch equatorial. That this system is one of the most difficult of celestial objects to observe, seems to be indicated by the paucity of the published measures. In Vol. X, Part I, of the Washburn Observatory Publications, Professor Comstock says, "I have examined this star frequently, but have never seen the companion."

As will be seen from the comparison (O−C) given below, the error of the ephemeris (depending on the orbit which I computed in 1889) will, according to the run of the residuals, be practically zero in 1897. The greatest deviation of the computed from the observed place, for the 290° of the orbit described since Burnham's first observation, took place in 1894, at which time the companion was about 17° in advance of the ephemeris-place.

Date	Position-Angle	Wt.	Distance	Wt.
	°		″	
1893.636	168.35	4	0.89	3
.644	168.10	6	0.90	5
.647	168.48	5	. .	. .
1894.468	180.34	5	. .	. .
.526	183.15	4	0.98	5
.528	181.50	8	0.79	1
.531	179.60	4	0.86	1
1894.643	182.00	6	. .	. .
.679	181.53	7	. .	. .
.736	181.00	4	0.71	2
1895.476	190.98	5	. .	. .
.514	188.74	7	1.08	4
.533	191.44	7	. .	3
.544	192.83	6	0.96	3
.550	193.70	6	0.89	3
.566	189.75	5	0.94	1
1896.776	204.16	10	0.77	4
.815	206.36	8	0.80	3
.856	207.50	3	0.72	4

To obtain the yearly normal places I have taken the simple mean of the times of observation, and the weighted means of the corresponding angles and distances.

Date	Position Angle	O − C	Distance	O − C
	°	°	″	″
1893.642	168.3	+10.4	0.90	+0.09
1894.587	181.3	+16.4	0.89	+0.20
1895.530	191.2	+14.5	1.02	+0.43
1896.816	205.5	+ 4.4	0.76	+0.27

Lick Observatory, 1896 *Nov.* 28.

NOTE ON THE CONVERGENCE OF THE SERIES IN ELLIPTICAL MOTION.

By A. HALL.

In the Supplement to the fifth volume of the *Mécanique Céleste* Laplace has determined the limiting value of the eccentricity for the convergence of the series, arranged in sines and cosines of multiples of the mean anomaly, which give the values of the radius-vector and the equation of center. For this value he finds

$$e = 0.66195.$$

This result is found by a very ingenious but complicated analysis. The simpler method given afterwards by CAUCHY, and which is deduced from the properties of complex quantities, gives

$$e = 0.6627434.$$

Although there is hardly a practical difference in these values, it may be worth while to point out that the formulas found by LAPLACE are strictly correct, and that his value of e is affected by a small numerical error in the solution of his first equation. The two equations found by LAPLACE are

$$\frac{1-\omega}{\omega} = e^{\frac{2}{1-2\omega}}$$

where e is the basis of natural logarithms, and from which ω is to be found by trial. Then the limiting value of e is found from the equation

$$e = \frac{2\cdot\sqrt{\omega(1-\omega)}}{1-2\omega}$$

It is evident from the first equation that a small error in ω will make a large residual in the equation. LAPLACE found $\omega = 0.08307$, and hence his value of e. But this value of ω does not satisfy the equation well. I find $\omega = 0.0832218$, and hence

$$e = 0.6627438,$$

and the results are in good agreement.

1896 *December* 9.

ON THE VARIATION OF SAWYER'S NEW SHORT-PERIOD VARIABLE IN *GEMINI*,*

BY W. E. SPERRA.

Observations were commenced on this star immediately after receiving *A.J.* 385 containing Mr. SAWYER's announcement of its variation. Though Mr. YENDELL in *A.J.* 386 published several minima and several isolated observations near maximum in confirmation of its variation, I deem it advisable to publish the following observations as an additional confirmation; they entirely verify the type of variation.

	M		M
1896 Oct 9.90	7.46	1896 Oct. 21.91	7.18
10.90	7.14	24.93	7.53
14.89	7.25	25.92	7.09
18.92	6.52	26.93	6.73
1896 Oct. 27.93	7.03	1896 Oct. 31.84	7.53
28.94	7.10	Nov. 1.93	7.67
30.97	7.38	2.93	7.31

The observations were made in the morning while the star was near the meridian. Upon comparing my observed maxima with the computed dates from Mr. SAWYER's elements, as given in his announcement, I find that my maxima occur nearly midway between the successive dates indicated by his elements: *e.g.* maxima are indicated by his elements for 1896 Oct. 22.52 and Oct. 30.26, while my observed date is Oct. 26.75.

Randolph, Ohio, 1896 *Nov.* 9.

A NEW VARIABLE OF SHORT PERIOD IN *SCORPIUS*,†

BY ROBERT H. WEST.

C.DM. —33°12533 = Arg. Gen. Catal. 24212. α (1875.0) = 17h 42m 36s.9 : δ (1875.0) = —33° 39′ 55″.5.

In the General Catalogue, the magnitude of this star is given as 6.9, while the C.DM. observations are (Vol. XVII, Introduction).

	M
1889 June 17	9
July 17	8
18	8.5

This star was observed here 1896 August 1, and twenty times between 1896 September 9 and November 9. There were no observations, however, between September 21 and October 19, except one on Oct. 7. These observations completely confirm the variability suspected at Cordoba, the magnitudes observed ranging from 7.45 to 8.8. Maxima are indicated for 1896 September 14.5 and October 22.5; the isolated observation of October 7, magnitude 7.8, shows that there was probably a maximum between these two. Hence the period is about 19 days. A minimum, 8.6, was observed 1896 November 5, somewhat uncertain because of the slight change in the star's light for several days, and it may be assumed that the observation of September 9, magnitude 8.8, was close to a minimum. These tend to confirm the period of 19 days, and show that the minimum falls 5 or 6 days before the maximum. A slight secondary maximum was observed on 1896 October 29.5.

The Cordoba observations show that the star's light was decreasing 1889 July 17, magnitude 8. According to my observations, this magnitude would occur six or seven days after maximum, which we can therefore place with considerable confidence on 1889 July 10 or 11. This is also consistent with the assumption that the observation on June 17 was at a minimum, and that a maximum occurred on June 22. These observations will enable us to determine the period with great exactness, on the assumption that it is regular, as soon as sufficient maxima have been observed to show with certainty how many periods have passed since that time.

Syrian Protestant College, Beirut, Syria, 1896 *Nov.* 10

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* 2335 *W Geminorum*; (1900) 6h 29m 14s +15° 24′.5 : (1855) 6h 26m 39s +15° 26′.3. — ED.

† 6385 *RY Scorpii*; (1900) 17h 44m 16s —33° 40′.5 : (1855) 17h 41m 18 —33° 39′.4. — ED.

OBSERVATIONS OF COMET 1889 V (*BROOKS = c 1896*),

MADE AT THE U.S. NAVAL OBSERVATORY WITH 26-INCH EQUATORIAL,

By Prof. STIMSON J. BROWN,

[Communicated by Prof. Wm. Harkness, U.S.N., Astronomical Director.]

1896 Washington M.T.	∗	No. Comp.	☄ − ∗ Δα	☄ − ∗ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m			m s	′ ″	h m s	° ′ ″		
July 17 13 55.6	1*a*	6 , 5	+0 13.46	−2 20.37	22 38 55.55	−18 14 44.2	*n*9.0459	0.8662
Aug. 3 13 0.2	2	8 , 5	−0 23.20	−2 4.01	22 37 7.87	−18 37 28.1	*n*8.9645	0.8691
4 14 10.6	2*a*	8 , 5	−0 23.54	−2 21.40	22 36 45.88	−18 39 15.7	*n*8.8606	0.8667
11 12 48.4	3*a*	7 , 8	−0 5.89	−0 52.85	22 33 39.29	−18 51 37.6	*n*8.6396	0.8711
14 12 17.8	4	16 , 5	+2 23.92	+0 24.50	22 32 0.48	−18 56 29.4	*n*8.9007	0.8715
28 11 19.4	5*a*	8 , 8	−0 8.34	−1 34.40	22 22 48.80	−19 9 0.4	*n*8.8279	0.8728
Sept. 1 10 37.3	6	20 , 5	−0 38.76	−2 36.65	22 20 3.99	−19 7 49.5	*n*9.0974	0.8695
4 9 55.4	6	27 , 5	−2 38.74	+0 2.74	22 18 4.11	−19 5 10.2	*n*9.2410	0.8649
8 10 7.4	7	6 , 6	−0 16.82	+2 30.32	22 15 31.37	−18 58 57.6	*n*9.0509	0.8698
Oct. 5 9 38.0	8	12 , 6	−2 59.12	−1 2.71	22 8 17.26	−16 54 54.1	*n*8.8060	0.8618
7 8 25.1	9	6 , 6	+0 3.29	+0 57.35	22 8 37.71	−16 40 47.3	*n*8.8718	0.8602
9 8 50.5	10	8 , 5	+0 2.12	−6 20.41	22 9 6.39	−16 25 31.2	*n*7.5244	0.8604

Mean Places for 1896.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 38 13.36	+3.56	−18 8 42.45	+19.39	½(Wash. + Mt. Hamilton)
1*a*	22 38 42.03	. .	−18 12 23.80	. .	From 1. Δα +25s.17, Δδ −4′ 0″.84
2	22 37 27.11	+3.96	−18 35 44.9	+20.84	½(Wash. + Mt. Hamilton)
2*a*	22 37 5.44	+3.98	−18 37 15.3	+21.00	From 2. Δα −21s.67, Δδ −1′ 30″.4
3	22 31 0.11	+4.15	−18 48 34.2	+20.57	½(Radcl. 6058 + Wash.)
3*a*	22 33 41.04	. .	−18 51 5.4	. .	From 3. Δα —2m 40s.93, Δδ −2′ 31″.08
4	22 29 32.37	+4.19	−18 57 14.4	+20.50	Weiss's Argelander 17477
5	22 23 11.30	+4.35	−19 15 12.3	+19.92	Wash. Meridian Circle 1896
5*a*	22 22 52.80	. .	−19 7 45.6	. .	From 6. Δα +2m 14s.59, Δδ −2′ 13″.4 From 5. Δα −18s.66, Δδ +7′ 26″.9
6	22 20 38.36	+4.39	−19 5 32.5	+19.70	½(Wash. + Mt. Hamilton)
7	22 15 43.78	+4.41	−19 1 46.8	+18.90	¼(2 Radcl. 6001 + M. I + M. II)
8	22 11 12.16	+4.24	−16 54 8.9	+17.44	½(Argelander + Wash. 1896)
9	22 8 30.22	+4.20	−16 42 1.7	+17.1	Wash. Meridian Circle. 1896
10	22 9 0.29	+4.18	−16 19 24.9	+14.1	" " " "

OBSERVATIONS OF COMET *g* 1896 (*PERRINE*),

MADE AT THE LICK OBSERVATORY WITH THE 12-INCH EQUATORIAL,

By C. D. PERRINE.

1896 Mt. Hamilton M.T.	∗	No. Comp.	☄ − ∗ Δα	☄ − ∗ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Dec. 8 12 23 14	1	*d*10 , 8	−0 33.09	+7 27.8	0 52 26.70	+6 24 51.9	9.650	0.704
9 7 31 16	2	*d*10 , 8	−0 17.21	−8 22.5	0 58 9.89	+6 4 30.0	*n*8.322	0.659
10 6 2 24	3	*a*10 , 8	−0 4.12	+0 39.9	1 4 51.94	+5 40 45.7	*n*9.305	0.670

Mean Places for 1896.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 52 55.67	+4.12	+6 16 56.3	+27.8	Paris 1246
2	0 58 22.96	+4.14	+6 12 24.8	+27.7	½(Schjellerup 356 + Paris 1366)
3	1 4 51.89	+4.17	+5 39 38.3	+27.5	Micrometer-comparison with ∗4
4	1 0 7.45	+4.14	+5 30 47.7	+27.4	Grant, Glasgow 264

All the comparisons in R.A. were made directly with the micrometer. The last observation was made through haze.

The comet has a well defined nucleus, and on the 8th there appeared to be a slight fan-shaped extension north preceding.

OBSERVATION OF COMET *g* 1896 (*PERRINE*),

MADE AT THE VASSAR COLLEGE OBSERVATORY.

BY PROF. MARY W. WHITNEY.

1896 Greenwich M.T.	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
Dec. 11 13h 22m 11s	1	13	−0m 32s.59	−3′ 56″.1	1h 11m 12s.62	+5° 16′ 43″.3	8.885	0.718

Mean Place for 1896.0 of Comparison-Star.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	1h 12m 41s.01	+4s.20	+5° 20′ 12″.1	+27″.2	½(Boss, Albany A.G.C. 353 + Schj. 408)

ELEMENTS OF COMET *g* 1896 (*PERRINE*),

BY W. J. HUSSEY AND C. D. PERRINE.

The following elements were derived from the Mt. Hamilton observations of Dec. 8, 9 and 10.

Residuals for the middle place (O−C).

$$\Delta\lambda' \cos\beta' = -1'' \quad , \quad \Delta\beta' = +3''$$

T = November 25.6659 Gr. M.T.

$$\left.\begin{aligned}\omega &= 164^\circ\ 36'\ \ 5'' \\ \Omega &= 243\ \ 48\ \ 40 \\ i &= \ \ 16\ \ 26\ \ 29\end{aligned}\right\}1896.0$$

$$\log q = 0.06220$$

ELEMENTS OF COMET *g* 1896 (*PERRINE*).

BY F. H. SEARES AND R. T. CRAWFORD.

From observations made at the Lick Observatory by Mr. C. D. PERRINE, on Dec. 8, 9, 10, we have computed the following elements for Comet *g* 1896 (Perrine). The observations were telegraphed to the Students' Observatory by Dr. HOLDEN.

Middle place, (O−C). $\Delta\lambda \cos\beta = +5''.5$, $\Delta\beta = 0''.0$

T = 1896 Nov. 21.7839 Gr. M.T.

$$\left.\begin{aligned}\omega &= 163^\circ\ 38'\ 14'' \\ \Omega &= 243\ \ 41\ \ \ 6 \\ i &= \ \ 16\ \ 39\ \ 57\end{aligned}\right\}1896.0$$

$$q = 1.15349$$

EPHEMERIS OF COMET *g* 1896 (*PERRINE*).

The ephemerides accompanying the above two sets of elements having expired, and no other elements being at hand, nor any recent observations from which a set might be computed for this issue of the *Journal*, the following extension of the ephemeris has been obtained from the above elements; although, being derived from single-day intervals, they are necessarily uncertain.

Gr. M.T.	α h m	δ ° ′	log. Δ	Br.
1896 Dec. 26.5	2 48.1	+0 32	9.616	0.57
30.5	3 9.7	−0 10	9.644	.48
1897 Jan. 3.5	3 29.2	−0 38	9.677	.40
7.5	3 46.7	−0 55	9.711	.32
11.5	4 0.0	−0 56	9.745	0.26

ED.

NOTICE.

Feeling the desirability of counsel and collaboration in the conduct of this *Journal*, the undersigned has invited Prof. ASAPH HALL and Prof. LEWIS BOSS to share in its editorship, and they have courteously accepted.

S. C. CHANDLER.

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NOTICE.

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THE SECULAR PERTURBATIONS OF *MERCURY* ARISING FROM THE ACTION OF *SATURN*,

By ERIC DOOLITTLE.

The method of performing the following computation is the same as that which was followed in obtaining the perturbations of *Mercury* arising from *Jupiter* (*Astronomical Journal*, no. 386). As the term a'^2e' is here larger than in the case of *Jupiter*, it was expected that the discordances in the sums of the functions corresponding respectively to the odd and even points of division would here also be larger, and the orbit of *Mercury* was accordingly divided into sixteen parts. An inspection of the final sums renders it evident, however, that a division into twelve parts would have been sufficient, while the error of the resulting differential coefficients which would have arisen from a division into only eight parts could not have exceeded 0″.000,000,02.

The computation was verified by a repetition from the beginning, and the usual test-equations were also applied. I am under much obligation to Mr. R. T. A. Innes for suggestions tending to lessen the amount of labor, and for verification formulas which were applied in repeating the work. Addition and subtraction tables of logarithms were used, but only in the duplication.*

The elements were adopted from Dr. G. W. Hill's "*New Theory of Jupiter and Saturn*," pages 192 and 558:

Mercury	*Saturn*
$\pi = 75^\circ\ 7'\ 13''.62$	$\pi' = 90^\circ\ 6'\ 41''.37$
$i = 7\ 0\ 7.71$	$i' = 2\ 29\ 40.19$
$\Omega = 46\ 33\ 8.63$	$\Omega' = 112\ 20\ 49.05$
$e = 0.20560476$	$e' = 0.05606025$
$\log a = 9.5878217$	$\log a' = 0.9794956$
$m = \frac{1}{5000000}$	$m' = \frac{1}{3501.6}$

Epoch, 1850.0 Greenwich Mean Time.

The preliminary constants were found to have the values:

$\Pi = 229^\circ\ 26'\ 43''.69$	$\log k = 9.9978013$
$\Pi' = 244\ 17\ 50.53$	$\log k' = 9.9994926$
$K = 345\ 17\ 17.36$	$\log c = 9.4563013$
$K' = 345\ 0\ 30.90$	$c = 0.28595737$
$I = 6\ 23\ 44.13$	

The resulting values of the auxiliary functions were then obtained as in the following tables.

E	log r	v	A	log B	ϵ	log q	h	l
		° ′ ″			° ′ ″			
0°	9.4878584	0 0 0.00	91.40055452	0.9008984	351 32 41.90	9.2141341	90.704247	+0.410351
22° 30′	9.4963313	27 32 14.92	91.41316673	0.9046508	4 37 44.47	9.0793905	90.704730	0.422480
45°	9.5195925	54 4 7.02	91.37113281	0.8912882	14 45 42.61	0.0512825	90.704973	0.380202
67° 30′	9.5522314	78 55 7.36	91.28182268	0.8600791	24 52 16.23	0.4241555	90.704844	0.291021
90°	9.5878217	101 51 53.65	91.15980423	0.8086753	34 50 7.51	0.5872603	90.704445	0.169403
112° 30′	9.6207149	123 3 1.59	91.02405557	0.7320584	44 25 1.78	0.6104619	90.704075	+0.034023
135°	9 6467730	142 49 52.77	90.89484135	0.6197894	53 4 23.29	0.5014117	90.704038	−0.095154
157° 30′	9.6633518	161 39 20.97	90.79086206	0.4177926	59 10 33.86	0.2196159	90.704442	−0.199537
180°	9.6690267	180 0 0.00	90.72697664	0.1490040	54 34 23.12	9.5764707	90.705145	−0.264126
202° 30′	9.6633518	198 20 39.03	90.71250891	9.8927735	340 51 2.51	8.2736779	90.705802	−0.279250
225°	9.6467730	217 10 7.23	90.75006384	0.3012347	307 16 55.42	9.8602291	90.706059	−0.241953
247° 30′	9.6207149	236 56 58.41	90.83489465	0.5349866	309 12 46.19	0.3046571	90.705781	−0.156844
270°	9.5878217	258 8 6.35	90.95505790	0.6784427	316 27 42.16	0.4894223	90.705088	−0.035987
292° 30′	9.5522314	281 4 52.64	91.09266180	0.7741018	325 17 28.22	0.5153493	90.704321	+0.102383
315°	9.5195925	305 55 52.98	91.22635509	0.8385407	334 46 8.59	0.3927481	90.703855	0.236543
337° 30′	9.4963313	332 27 45.08	91.33481374	0.8794967	344 34 1.45	0.0654177	90.703855	+0.345001
Σ_1			728.48478638		1470 18 4.60		725.637848	+0.559279
Σ_2			728.48478617		1453 0 54.71		725.637850	+0.559277

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* The following error occurs in Zech's "*Tafeln der Additions-und Subtractions-Logarithmen.* Second edition: on page 723. 1.3765975 should be 1.3765795

E	G	G'	G''	θ ° ′ ″	$\log \mathfrak{K}$	$\log \mathfrak{T}'$	$\log \mathfrak{N}$	$\log N$
0°	90.704 227	0.414 7226	0.004 3526	3 53 50.78	0.001 50875	0.275 01245	0.178 35367	5.628 5747
22° 30′	90.704 715	0.425 6040	0.003 1100	3 56 31.53	0.001 54356	0.275 05883	0.178 40585	5.645 5608
45°	90.704 836	0.410 5578	0.030 2188	3 59 47.96	0.001 58664	0.275 11623	0.178 47042	5.691 9307
67° 30′	90.704 520	0.370 3889	0.079 0439	4 2 4.89	0.001 61702	0.275 15671	0.178 51595	5.756 8907
90°	90.703 974	0.308 1768	0.138 3038	4 1 12.34	0.001 60533	0.275 14113	0.178 49842	5.827 6384
112° 30′	90.703 579	0.230 0012	0.195 4823	3 55 22.98	0.001 52867	0.275 03898	0.178 38353	5.892 9111
135°	90.703 652	0.145 5476	0.240 3156	3 41 5.05	0.001 38529	0.274 84791	0.178 16860	5.944 5922
157° 30′	90.704 241	0.068 3029	0.267 6388	3 29 2.13	0.001 20533	0.274 60806	0.177 89879	5.977 3700
180°	90.705 099	0.014 9026	0.278 9825	3 15 29.12	0.001 05402	0.274 40638	0.177 67493	5.988 4810
202° 30′	90.705 800	0.000 7394	0.279 9874	3 11 3.15	0.001 00673	0.274 34335	0.177 60102	5.977 0716
225°	90.705 971	0.029 4521	0.271 3169	3 17 46.29	0.001 07884	0.274 43945	0.177 70944	5.944 0470
247° 30′	90.705 536	0.090 4199	0.246 7190	3 29 20.24	0.001 20882	0.274 61270	0.177 90402	5.892 2401
270°	90.704 713	0.167 5089	0.203 1209	3 39 39.24	0.001 33101	0.274 77556	0.178 08722	5.826 8942
292° 30′	90.703 922	0.248 2641	0.145 4820	3 46 28.97	0.001 41515	0.274 88768	0.178 21333	5.756 2165
315°	90.703 554	0.321 5440	0.081 7000	3 50 7.92	0.001 46116	0.274 94901	0.178 28232	5.691 4235
337° 30′	90.703 713	0.378 9646	0.033 8216	3 52 2.72	0.001 48559	0.274 98156	0.178 31893	5.645 2895
Σ_1	725.636 026	1.812 4124	1.251 3111	29 41 58.70	0.011 01404	1.198 68812	1.425 24172	6.543 5816
Σ_2	725.636 026	1.812 3850	1.251 2850	29 41 56.64	0.011 01087	1.198 68787	1.425 24142	6.543 5802

E	$\log P$	$\log Q$	$\log V$	$\log J_1$	$\log J_2$	$\log J_3$	$\log F_2$	$\log F_3$
0°	1.988 2904	3.849 2800	3.849 2539	1.954 5232	n9.776 3566	n0.781 5570	0.583 1679	n9.345 7996
22° 30′	2.005 3300	3.866 3219	3.866 3033	1.952 4936	n9.322 1248	n0.898 2246	n0.515 7961	8.826 5203
45°	2.051 4967	3.912 6260	3.912 4452	1.952 6460	9.565 0707	n0.920 5549	n1.001 7421	n9.351 7097
67° 30′	2.146 0330	3.977 3995	3.976 9269	1.954 6798	9.856 4597	n0.859 4825	n1.188 1786	n9.995 0076
90′	2.186 2035	4.047 8488	4.047 0220	1.957 0442	9.832 2989	n0.681 1925	n1.269 7310	n0.262 4131
112° 30′	2.250 8613	4.112 7652	4.111 5969	1.958 4675	9.552 1845	n0.143 1082	n1.281 3318	n0.360 0566
135°	2.301 8923	4.163 9869	4.162 5507	1.958 5303	n8.683 5427	0.393 1681	n1.226 8067	n0.325 2782
157° 30′	2.334 1639	4.196 3617	4.194 7623	1.957 4678	n9.561 2433	0.792 4788	n1.085 9088	n0.143 6093
180°	2.344 9566	4.207 1875	4.205 5204	1.955 8455	n9.692 7744	0.965 0896	n0.764 3362	n9.708 1362
202° 30′	2.333 4678	4.195 6990	4.191 0258	1.954 3336	n9.612 1465	1.044 9706	0.112 9398	8.815 5382
225°	2.300 6205	4.162 8231	4.161 2018	1.953 5341	n9.194 4162	1.060 9912	0.906 2154	8.786 0267
247° 30′	2.249 2258	4.111 3306	4.109 8562	1.953 8295	9.191 5050	1.017 6432	1.128 4294	n9.661 5362
270°	2.184 4672	4.046 3801	4.045 1660	1.955 2056	9.556 0329	0.901 8986	1.220 8120	n0.055 6209
292° 30′	2.114 4600	3.976 1077	3.975 2380	1.957 0159	9.466 4516	0.659 8382	1.233 7755	n0.187 5637
315°	2.050 3133	3.911 6762	3.911 1697	1.957 9947	n8.867 2278	9.849 3088	1.172 4749	n0.152 3974
337° 30′	2.004 6971	3.865 8214	3.865 6191	1.957 0355	n9.700 5135	n0.480 1684	1.008 8097	n9.934 3334
Σ_1	7.408 2388	2.301 8068	2.294 3297	5.645 3236				
Σ_2	7.408 2403	2.301 8085	2.294 3284	5.645 3232				

E	$\log R_0$	$\log S_0$	$\log W_0$	$R_0 \sin v + (\cos v+\cos E)\, S_0$	$-R_0 \cos v + \left(\frac{r}{a}\sec^2\varphi+1\right)\sin v\, S_0$
0°	5.318 8055	n3.585 4734	n4.631 0301	−0.000 000 770 023	−0.000 020 835 5810
22° 30′	5.329 5936	n3.273 0503	n4.764 4772	+0.000 009 535 644	−0.000 019 099 7850
45°	5.375 9563	3.272 3778	n4.833 1615	0.000 019 486 084	−0.000 013 659 3860
67° 30′	5.446 2915	3.681 1553	n4.837 2260	0.000 027 699 067	−0.000 004 446 9025
90°	5.523 1601	3.673 6441	n4.730 4898	0.000 032 545 329	+0.000 007 801 5052
112° 30′	5.591 6968	3.081 0801	n4.264 4575	0.000 032 625 198	0.000 021 515 5020
135°	5.642 6592	n3.610 6508	4.550 5688	0.000 027 148 276	0.000 034 456 5700
157° 30′	5.671 6442	n3.920 7714	4.985 8953	0.000 016 337 313	0.000 043 976 9600
180°	5.677 5411	n3.963 7080	5.170 2785	+0.000 001 839 662	0.000 047 592 7904
202° 30′	5.661 4580	n3.786 7777	5.239 0316	−0.000 013 287 669	0.000 043 963 8934
225°	5.626 1643	n2.818 1151	5.222 2249	−0.000 025 446 823	0.000 033 780 8016
247° 30′	5.575 7800	3.642 2114	5.127 2357	−0.000 031 966 152	0.000 019 752 2136
270°	5.515 5121	3.815 2246	4.946 2111	−0.000 032 206 863	+0.000 005 430 9792
292° 30′	5.451 4310	3.698 5015	4.633 0544	−0.000 027 462 505	−0.000 006 396 5152
315°	5.390 7139	3.029 3576	4.748 2858	−0.000 019 770 536	−0.000 014 592 2640
337° 30′	5.342 6141	n3.423 3810	n4.347 4864	−0.000 010 655 672	−0.000 019 289 9750
Σ_1	* +0.000 269 11202	* −0.000 000 359 24718	*0.000 027 967 152	+0.000 002 825 107	0.000 079 975 3913
Σ_2	* +0.000 269 11193	* −0.000 000 359 24707	*0.000 027 967 125	+0.000 002 825 224	0.000 079 975 4154

* The corresponding numbers have been added.

E	$W_0 \sin u$	$W_0 \cos u$	$-\frac{2}{a} r R_0$	$\log \frac{1}{a} \sin E\, R^{(n)}$	$\log \frac{1}{a} S^{(n)}$
0°	−0.000 002 044 7571	−0.000 003 755 3340	−0.000 033 103 367	. . . .	n4.097 6150
22° 30′	−0.000 004 826 0289	−0.000 003 242 2806	−0.000 034 604 548	5.416 1020	n3.776 7190
45°	−0.000 006 754 0641	−0.000 000 872 8046	−0.000 040 621 607	5.705 8488	3.752 7853
67° 30′	−0.000 006 556 5758	+0.000 002 065 6152	−0.000 051 490 988	5.859 6754	4.128 9239
90°	−0.000 004 092 3123	0.000 003 486 8920	−0.000 066 709 877	5.935 3384	4.085 8224
112° 30′	−0.000 000 873 9008	+0.000 001 617 4933	−0.000 084 259 712	5.936 5972	3.460 3652
135°	+0.000 000 531 3050	−0.000 003 512 8323	−0.000 100 609 845	5.845 3712	n3.963 8778
157° 30′	−0.000 001 718 2294	−0.000 009 526 7356	−0.000 111 738 865	5.591 1321	n4.257 4196
180°	−0.000 007 077 6661	−0.000 012 998 6018	−0.000 114 756 176	. . . .	n4.294 6813
202° 30′	−0.000 012 663 0324	−0.000 011 844 7875	−0.000 109 148 595	n5.580 9459	n4.123 4259
225°	−0.000 015 207 6154	−0.000 006 854 7683	−0.000 096 860 250	n5.828 8763	n3.171 3424
247° 30′	−0.000 013 363 0400	−0.000 001 047 5614	−0.000 081 227 519	n5.920 6804	4.021 4965
270°	−0.000 008 462 3118	+0.000 002 539 3222	−0.000 065 545 379	n5.927 6904	4.227 4029
292° 30′	−0.000 003 307 6901	0.000 002 741 1608	−0.000 052 103 952	n5.864 8149	4.146 2701
315°	−0.000 000 241 1456	+0.000 000 505 5592	−0.000 042 025 673	n5.720 6064	3.509 7651
337° 30′	−0.000 000 040 0332	−0.000 002 225 4410	−0.000 035 657 730	n5.429 1225	n3.927 0497
Σ_1	−0.000 043 348 422	−0.000 021 462 570	−0.000 560 23241	*0.000 002 36573	*−0.000 000 495 546
Σ_2	−0.000 043 348 570	−0.000 021 462 536	−0.000 560 23202	*0.000 002 35876	*−0.000 000 495 578

* The corresponding numbers have been added.

The equation,

$$\sin q\, \tfrac{1}{2}\, (A_1)^{(s)} + \cos q\, B_0^{(c)} = 0$$

is found to give as a residual

$$+0.000\,000\,000\,034$$

The values of the differential coefficients are as follows:

		log coeff.
$\left[\frac{de}{dt}\right]_{00}$	$= +\ 1''.859\,683\, m'$	p0.269 4389
$\left[\frac{d\chi}{dt}\right]_{00}$	$= +256.046\,18\ m'$	p2.408 3183
$\left[\frac{di}{dt}\right]_{00}$	$= -\ 14.751\,452\, m'$	n1.168 8348
$\left[\frac{d\Omega}{dt}\right]_{00}$	$= -241.399\,83\ m'$	n2.388 1009
$\left[\frac{d\pi}{dt}\right]_{00}$	$= +254.223\,35\ m'$	p2.405 2154
$\left[\frac{dL}{dt}\right]_{00}$	$= -373.179\,67\ m'$	n2.571 9180

By substituting the above value for m', there are finally obtained the following results:

$$\left[\frac{de}{dt}\right]_{00} = +0''.000\,531\,0952$$

$$\left[\frac{d\chi}{dt}\right]_{00} = +0.073\,122\,627$$

$$\left[\frac{di}{dt}\right]_{00} = -0.004\,212\,776$$

$$\left[\frac{d\Omega}{dt}\right]_{00} = -0.069\,796\,619$$

$$\left[\frac{d\pi}{dt}\right]_{00} = +0.072\,602\,050$$

$$\left[\frac{dL}{dt}\right]_{00} = -0.106\,574\,05$$

If the value of m' employed by LeVerrier be adopted, ($m' = \frac{1}{3512}$) (*Annales de l'Observatoire de Paris*, Tome V), the results from the two methods may be compared as follows:

	Method of Gauss	Method of LeVerrier
$\left[\frac{de}{dt}\right]_{00} =$	+0''.000 5295	+0''.00053
$\left[\frac{di}{dt}\right]_{00} =$	−0.004 2003	−0.00420
$\left[\frac{d\Omega}{dt}\right]_{00} =$	−0.069 590	−0.0698
$\left[\frac{dL}{dt}\right]_{00} =$	−0.106 259	−0.1067
$\left[\frac{d\pi}{dt}\right]_{00} =$	+0.072 387	+0.0724

The Flower Observatory, 1896 *Dec.* 16.

NEW ASTEROID.

Prof. Kreutz has communicated the discovery of a new asteroid, 1896 *DB*, by Charlois, at Nice, in the following position:

DB 11ᴹ 1896 Dec. 7 $10^{h}\ 57^{m}.8$ Nice M.T. $\alpha = 3^{h}\ 7^{m}\ 56^{s}$, $\delta = +13°\ 46'$. Daily motion, -40^{s} on parallel.

OBSERVATIONS OF COMET 1895 IV,

MADE AT THE LICK OBSERVATORY WITH THE 12-INCH AND 36-INCH EQUATORIALS,

By C. D. PERRINE.

1896 Mt. Hamilton M.T.		∗	No. Comp.	☄ — ∗ Δα	☄ — ∗ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Mar. 22	16 57 39	49	10 , 4	+1 34.12	+2 45.5	19 41 52.68	+ 8 11 42.3	n9.501	0.657
23	16 29 11	50	9 , 4	+1 42.22	+0 7.0	19 41 23.17	+ 8 28 30.5	n9.531	0.660
28	16 1 55	51	3 , 3	−0 1.13	+0 57.3	19 38 30.74	+ 9 54 25.9	n9.540	0.647
29	16 2 38	53	3 , 3	+0 5.49	−0 55.6	19 37 50.61	+10 10 48.1	n9.531	0.642
31	16 27 16	55	5 , 5	−0 14.54	−0 35.4	19 36 25.40	+10 45 17.8	n9.458	0.604
Apr. 7	16 9 39	57	13 , 14	+0 6.99	+2 0.3	19 30 35.40	+12 45 4.9	n9.428	0.592
10	15 21 33	59	5 , 5	+0 5.26	+0 33.2	19 27 38.39	+13 35 33.9	n9.505	0.595
11	15 35 27	61	10 , 10	−0 2.62	+0 12.9	19 26 34.43	+13 52 37.1	n9.462	0.582
12	14 47 15	63	10 , 10	+0 2.66	−1 0.0	19 25 31.17	+14 8 59.2	n9.553	0.603
15	11 55 2	65	10 , 15	−0 21.12	−0 2.5	19 22 3.12	+14 59 23.0	n9.511	0.579
16	15 25 57	67	14 , 11	−0 30.27	−4 31.5	19 20 48.15	+15 16 13.6	n9.418	0.555
17	14 34 9	68	10 , 10	+0 13.74	+0 50.5	19 19 35.82	+15 32 11.9	n9.533	0.579
19	14 51 47	69	12 , 10	−0 2.33	+0 39.3	19 16 58.66	+16 5 8.1	n9.470	0.553
May 6	12 58 6	71	10 , 8	−0 12.72	+2 9.4	18 49 47.94	+20 15 36.3	n9.526	0.505
7	14 48 19	72	6 , 6	+0 1.84	−0 16.4	18 47 47.29	+20 29 32.6	n9.041	0.415
11	14 6 11	74	7 , 6	+0 20.76	−1 46.6	18 40 6.11	+21 16 51.6	n9.185	0.405
12	12 26 39	76	10 , 7	−0 28.16	+0 21.6	18 38 14.56	+21 27 24.0	n9.524	0.481
13	12 31 37	77	14 , 10	−0 14.72	+2 33.8	18 36 13.38	+21 38 10.2	n9.497	0.467
15	12 29 54	78	10 , 10	−0 6.70	−2 6.0	18 32 8.89	+21 58 54.8	n9.474	0.450
16	12 20 11	79	10 , 10	−0 21.39	−4 1.2	18 30 5.64	+22 8 33.1	n9.484	0.436
18	13 27 2	81	10 , 10	−0 8.32	+1 43.7	18 25 49.40	+22 27 30.2	n9.176	0.373
23	14 51 22	83	5	. . .	+0 54.6	. . . .	+23 6 55.2	. .	0.341
	15 10 10	83	8	−1 3.49	. . .	18 15 0.65	. . . .	n9.153	. .
24	11 27 23	84	16 , 7	−0 38.80	−2 37.9	18 13 11.51	+23 12 33.3	n9.498	0.436
31	11 42 36	85	15 , 9	−1 1.52	−0 56.4	17 58 2.19	+23 47 23.9	n9.312	0.358
June 6	12 9 40	86	5 , 5	−0 5.53	−4 26.1	17 45 14.27	+24 1 4.4	n8.851	0.310
7	11 40 37	88	10	. . .	−5 29.8	. . . .	+24 1 53.7	. .	0.320
9	13 10 31	90	10 , 8	−0 3.41	−1 52.1	17 38 55.01	+24 2 24.4	9.029	0.318
13	13 21 50	91	10 , 10	−0 1.22	−3 21.9	17 30 51.91	+23 58 43.8	9.265	0.342
14	13 19 43	92	10 , 10	+0 0.86	−2 29.8	17 28 54.67	+23 56 55.9	9.303	0.350
28	9 55 46	93	10 , 10	−0 5.05	+4 22.3	17 4 32.72	+23 0 1.5	n8.940	0.342
July 4	11 15 3	95	8 , 6	−0 2.80	+0 1.5	16 55 42.20	+22 20 24.8	9.201	0.380
5	11 10 41	97	10 , 8	+0 0.95	−0 41.2	16 54 21.51	+22 13 16.6	9.212	0.384
11	12 11 21	98	10 , 8	−0 12.78	+0 51.1	16 46 53.18	+21 26 44.5	9.590	0.522
12	11 18 37	101	10 , 8	−0 14.95	+2 19.6	16 45 49.57	+21 19 1.7	9.494	0.471
	11 49 16	103	10	−0 3.51	. . .	16 45 48.40	. . . .	9.504	. .
15	11 47 56	104	10 , 8	+0 15.54	−2 32.5	16 42 37.87	+20 54 1.3	9.528	0.494
	11 18 26	106	10 , 8	+0 7.31	+0 55.8	16 42 39.31	+20 54 8.4	9.455	0.465
Aug. 1	10 32 3	108	10 , 8	−0 15.08	+2 11.4	16 29 41.44	+18 24 17.0	9.512	0.529
2	9 17 36	111	10 , 8	−0 7.83	−2 57.5	16 29 11.63	+18 15 56.9	9.299	0.486
5	9 25 9	112	10 , 8	−0 3.88	+2 47.9	16 27 45.95	+17 48 49.7	9.405	0.511
6	9 16 9	114	10 , 8	+0 12.78	−3 11.9	16 27 21.30	+17 39 57.3	9.396	0.511
8	11 32 31	115	10 , 8	−0 11.32	−1 55.4	16 26 32.39	+17 21 13.9	9.647	0.622
9	10 12 10	117	10 , 8	+0 10.36	+0 6.0	16 26 12.21	+17 12 59.7	9.547	0.560

Mean Places for 1896.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
49	19 40 17.94	+0.62	+ 8 9 11.8	−15.0	½(Munich 1, 21672 + W.B. XIX, 983)
50	19 39 40.30	+0.65	+ 8 28 38.7	−15.2	Tucker, L.O. meridian circle
51	19 38 31.10	+0.77	+ 9 53 44.2	−15.6	Micrometer-comparison with ∗52
52	19 36 13.38	+0.78	+ 9 49 1.5	−15.7	Schjellerup 7532
53	19 37 44.32	+0.80	+10 11 59.4	−15.7	Micrometer-comparison with ∗51
54	19 34 23.98	+0.82	+10 9 1.9	−15.9	Schjellerup 7506
55	19 36 39.09	+0.85	+10 46 9.0	−15.8	Micometer-comparison with ∗56
56	19 39 15.68	+0.84	+10 39 44.3	−15.6	½(W.B. XIX, 971 + Munich I. 21643)

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
57	19 30 27.32	+1.09	+12 43 20.9	−16.3	Micrometer-comparison with *58
58	19 32 56.33	+1.08	+12 42 19.0	−16.1	Schjellerup 7482
59	19 27 31.95	+1.18	+13 35 17.4	−16.7	Micrometer-comparison with *60
60	19 28 59.89	+1.16	+13 38 55.6	−16.5	$\frac{1}{3}$(2 Schj. 7429 + W.B. XIX, 683)
61	19 26 35.85	+1.20	+13 52 40.8	−16.6	Micrometer-comparison with *62
62	19 23 15.31	+1.22	+13 51 38.3	−16.7	$\frac{1}{2}$(W.B. XIX, 524 + Munich I, 20309)
63	19 25 27.58	+1.23	+14 10 15.8	−16.6	Micrometer-comparison with *64
64	19 22 46.82	+1.25	+14 4 20.9	−16.7	$\frac{1}{3}$(2 Munich II, 8747 + 1 W.B. XIX, 511)
65	19 22 22.91	+1.33	+14 59 42.1	−16.6	Micrometer-comparison with *66
66	19 24 40.72	+1.32	+14 58 14.2	−16.5	Auwers, Berlin A.G. Catal. 7480
67	19 21 17.05	+1.37	+15 21 1.7	−16.6	“ “ “ “ 7435
68	19 19 20.67	+1.41	+15 31 38.0	−16.6	Tucker, L.O. meridian circle
69	19 16 59.50	+1.49	+16 4 45.4	−16.6	Micrometer-comparison with *70
70	19 17 45.83	+1.48	+16 8 11.2	−16.6	Tucker, L.O. meridian circle
71	18 49 58.56	+2.10	+20 13 43.1	−16.2	Becker, Berlin A.G. Catal. 6726
72	18 47 43.32	+2.13	+20 30 5.2	−16.2	Micrometer-comparison with *73
73	18 50 3.94	+2.12	+20 29 3.0	−16.1	Becker, Berlin A.G. Catal. 6729
74	18 39 43.09	+2.26	+21 18 53.9	−15.7	Micrometer-comparison with *75
75	18 38 40.43	+2.26	+21 27 17.9	−15.7	Becker, Berlin A.G. Catal. 6615
76	18 38 40.43	+2.29	+21 27 17.9	−15.5	“ “ “ “ 6615
77	18 36 25.77	+2.33	+21 35 51.7	−15.3	“ “ “ “ 6601
78	18 32 13.18	+2.41	+22 1 16.0	−15.2	“ “ “ “ 6565
79	18 30 24.59	+2.44	+22 12 49.2	−14.9	Micrometer-comparison with *80
80	18 30 48.30	+2.41	+22 13 43.6	−14.9	Becker, Berlin A.G. Catal 6548
81	18 25 55.21	+2.51	+22 26 1.2	−14.7	Micrometer-comparison with *82
82	18 27 34.28	+2.50	+22 20 10.7	−14.6	Becker, Berlin A.G. 6519
83	18 16 1.50	+2.64	+23 6 14.4	−13.8	“ “ “ 6419
84	18 13 47.64	+2.67	+23 15 24.9	−13.7	“ “ “ 6398
85	17 59 0.84	+2.87	+23 48 32.5	−12.2	“ “ “ 6277
86	17 45 16.84	+2.96	+24 5 41.5	−11.0	Micrometer-comparison with *87
87	17 45 2.12	+2.96	+24 12 29.7	−11.0	Becker, Berlin A.G. Catal. 6147
88	17 43 18.11	+2.98	+24 7 34.2	−10.7	Micrometer-comparison with *89
89	17 39 36.17	+2.99	+24 7 24.5	−10.8	Becker, Berlin A.G. Catal. 6111
90	17 38 55.41	+3.01	+24 4 26.7	−10.2	Micrometer-comparison with *89
91	17 30 50.05	+3.08	+24 2 15.1	− 9.4	Becker, Berlin A.G. Catal. 6034
92	17 28 50.72	+3.09	+23 59 34.9	− 9.2	“ “ “ “ 6024
93	17 4 34.60	+3.17	+22 55 45.6	− 6.4	Micrometer-comparison with *94
94	17 7 10.46	+3.17	+22 51 5.3	− 6.4	Becker, Berlin A.G. Catal. 5882
95	16 55 41.87	+3.13	+22 20 28.6	− 5.3	Micrometer-comparison with *96
96	16 51 54.93	+3.12	+22 16 15.6	− 5.4	Becker, Berlin A.G. Catal. 5774
97	16 54 17.44	+3.12	+22 14 2.9	− 5.1	Micrometer-comparison with *96
98	16 47 2.85	+3.11	+21 25 57.8	− 4.4	“ “ “ *99 and *100
99	16 50 38.21	+3.12	+21 32 0.8	− 4.4	Becker, Berlin A.G. Catal. 5768
100	16 49 17.96	+3.12	+21 20 33.9	− 4.3	“ “ “ “ 5762
101	16 46 1.42	+3.10	+21 16 46.4	− 4.3	Micrometer-comparison with *102
102	16 48 12.03	+3.11	+21 8 49.3	− 4.3	Becker, Berlin A.G. Catal. 5755
103	16 45 48.78	+3.13	+21 21 47.4	− 4.1	Micrometer-comparison with *100
104	16 41 19.31	+3.02	+20 56 35.6	− 1.8	“ “ “ *105
105	16 38 59.98	+3.01	+20 54 43.8	− 1.9	Becker, Berlin A.G. Catal. 5706
106	16 42 28.98	+3.02	+20 53 14.4	− 1.8	Micrometer-comparison with *107
107	16 39 5.01	+3.01	+20 53 33.3	− 1.9	Becker, Berlin A.G. Catal. 5707
108	16 29 53.65	+2.87	+18 22 8.2	− 2.6	Micrometer-comparison with *109 and *110
109	16 33 1.37	+2.88	+18 30 5.8	− 2.4	Auwers, Berlin A.G. Catal. 5957
110	16 34 48.50	+2.89	+18 23 51.9	− 2.4	“ “ “ “ 5968
111	16 29 16.60	+2.86	+18 18 56.9	− 2.5	Micrometer-comparison with *109 and *110
112	16 27 47.00	+2.83	+17 46 4.2	− 2.4	“ “ “ *113
113	16 26 45.49	+2.83	+17 43 26.2	− 2.5	Auwers, Berlin A.G. Catal. 5920
114	16 27 9.27	+2.82	+17 43 16.9	− 2.4	Micrometer-comparison with *113
115	16 26 40.91	+2.80	+17 23 11.7	− 2.4	“ “ “ *116
116	16 26 49.47	+2.80	+17 25 52.3	− 2.4	Auwers, Berlin A.G. Catal. 5922
117	16 25 59.07	+2.78	+17 12 56.1	− 2.4	Micrometer-comparison with *118 and *119
118	16 27 49.35	+2.79	+17 4 6.7	− 2.4	Auwers, Berlin A.G. Catal. 5926
119	16 30 46.57	+2.80	+17 16 18.1	− 2.4	“ “ “ “ 5945

NOTES.

Except on March 22, 23, May 23, 24 and 31, the differences of right-ascension were measured directly with the micrometer.

Beginning May 23, the observations were made with the 36-inch equatorial.

Prof. TUCKER has kindly determined the places of a number of comparison-stars with the meridian circle.

Mt. Hamilton, 1896 *Dec.* 7.

MICROMETRIC OBSERVATIONS OF THE SATELLITE OF *NEPTUNE*,

BY J. M. SCHAEBERLE.

The present series of observations forms the continuation of the set published in no. 340 of the *Astronomical Journal*. Unless otherwise stated, the measures were made with bright wires, and a magnifying power of 520 diameters.

Date	Pac. Standard Time	Position Angle	Distance	No. of Comp.	Remarks
1895	h m s	°	″		
Oct. 21	12 31 43	219.95	14.18	6	Telescope swaying
	12 50 45			10	
	13 9 16	218.26		5	
Oct. 25	12 4 15	314.59	10.58	7	Poor seeing
	12 25 20			10	
	12 39 52	311.63		6	
Oct. 27	11 32 16	258.06	16.52	5	Poor seeing
	11 46 56			10	
	11 58 37	257.58		5	
Oct. 28	11 23 56	216.36	13.68	5	Seeing 3
	11 38 44			10	
	11 52 21	215.50		5	
Oct. 29	11 29 26	129.86	10.99	7	Satellite very faint, owing to moonlight
	11 49 4			11	
	12 8 4	128.50		5	
Nov. 9	11 7 13	202.15	12.04	6	
	11 38 8			10	
	12 1 45	199.01		5	
Nov. 16	10 49 34	105.4±	. .	5	Strong wind; telescope swaying badly
Nov. 20	10 0 57	240.86	16.81	5	Mag. power 800 diameters
	10 15 43			10	
	10 28 35	240.38		5	
Dec. 1	8 39 34	274.03	. .	6	Obs'd with dark wires, bright field due to moonlight
	10 18 25	270.65		4	
Dec. 7	9 13 18	266.40	15.54	5	
	9 31 29			10	
	9 47 3	264.84		5	
Dec. 9	9 3 35	154.20	10.23	5	
	9 13 15			10	
	9 29 3	153.30		6	
Dec. 31	7 56 40	248.83	16.76	5	Poor seeing
	8 15 6			10	
	8 35 47	247.71		5	
1896 Jan. 1	8 42 58	201.15	. .	5	Fixed wire broken
Jan. 2	8 39 4	112.91	11.96	5	Poor seeing
	8 59 6			10	
	9 16 23	111.39		5	
Feb. 21	7 40 40	292.22	11.61	5	Satellite very faint, owing to thin clouds
	7 56 18			10	
	8 6 19	290.66		5	
Oct. 16	12 21 55	102.04	13.90	5	Strong wind; telescope swaying badly
	12 59 49			10	
	13 19 0	98.94		5	
Oct. 17	12 34 17	59.67	16.30	5	Thick sky; satellite very faint
	12 57 56			11	
	13 28 23	58.79		5	
Oct. 27	11 43 45	162.81	10.07	5	Satell. faint and blurred; strong wind swaying telescope
	11 59 41			11	
	12 17 4	161.85		5	
Oct. 28	11 11 36	92.03	15.30	5	Mag. power 800 diameters
	11 27 01			10	
	11 41 16	91.35		5	
Oct. 29	10 45 23	52.53	15.49	5	Thick sky; later satellite could no longer be seen
	11 27 18			10	
Oct. 30	12 41 39	334.10	10.09	5	Satellite very faint; later both satell. and *Neptune* invisible
	13 0 32			10	
Nov. 6	12 58 45	260.51	16.72	5	Wind swaying telescope; excellent seeing
	13 25 10			10	
	13 44 58	258.45		5	

Lick Observatory, 1896 *Dec.* 21.

TRAJECTORY OF THE POLE, FOR COMPUTING LATITUDE-VARIATIONS IN 1897,

By S. C. CHANDLER.

The following tables for finding variations of latitude in 1897 are a continuation of those given in *A.J.* XV, 193. The basis is the same, and full explanation has been there given. Polar as well as rectangular coordinates are given. The variations of latitude for any place in longitude λ (reckoned positive west from Greenwich), are found by either of the two formulas,

$$\varphi - \varphi_0 = x \sin\lambda - y \cos\lambda \,, \quad \text{or} \quad -r\cos(a+\lambda)$$

according to convenience. Or the variations may be computed directly, without the use of the coordinates, by means of

$$\varphi - \varphi_0 = -r_1 \cos[\lambda + (t - T_1)\theta] - r_2 \cos(\odot - G')$$

where T_1, θ and r_1 may be taken from the table at top of p. 194, l.c., and the constants r_2 and G' may be found from

$$r_2 \sin G' = -0''.0550 \sin\lambda$$
$$r_2 \cos G' = -0''.0953 \sin\lambda + 0''.1100 \cos\lambda$$

See *A.J.* XIV, 132, where these constants are given for various stations. Or we may use

$$\varphi - \varphi_0 = -r_1 \cos[\lambda + (t - T_1)\theta]$$
$$\qquad -0''.11 \cos\lambda \cos\odot + 0''.11 \sin\lambda \sin(\odot - 300°)$$

All four of the above formulas give absolutely identical numerical results. ⊙ is the longitude of the mean sun.

Coordinates of the Pole for 1897.

1897	Rectangular		Polar	
	x	y	r	a
	″	″	″	°
Jan. 4	+0.019	+0.159	0.160	6.8
24	.093	.174	.198	28.2
Feb. 13	.157	.171	.233	42.6
Mar. 5	.208	.154	.259	53.6
25	.237	.117	.266	63.7
Apr. 14	.244	.067	.254	74.7
May 4	.226	+0.009	.226	87.7
24	.186	−0.053	.194	105.9
June 13	.126	.110	.167	131.1
July 3	+0.054	.159	.168	161.2
23	−0.025	.193	.195	187.4
Aug. 12	.101	.209	.232	205.8
Sept. 1	.166	.204	.264	219.1
21	.215	.178	.279	230.4
Oct. 11	.242	.133	.276	241.2
31	.244	.073	.255	253.3
Nov. 20	.223	−0.006	.223	268.5
Dec. 10	.178	+0.065	.189	290.1
30	.115	.128	.172	318.1
50	−0.042	+0.182	0.187	347.0

The variations of latitude for four principal meridians are given below. Those for Greenwich may be taken directly from the first table, being the values of y with the opposite sign.

Cambridge, 1896 *Dec.* 29.

Variations of Latitude in 1897, $\varphi - \varphi_0$.

1897	Pulkowa	Berlin	Paris	Washington
	″	″	″	″
Jan. 4	−0.147	−0.159	−0.160	−0.017
24	.197	.192	.178	+0.052
Feb. 13	.227	.204	.177	.115
Mar. 5	.238	.198	.162	.169
25	.221	.169	.126	.205
Apr. 14	.181	.122	.077	.223
May 4	.122	−0.060	−0.018	.218
24	−0.048	+0.009	+0.046	.193
June 13	+0.031	.078	.105	.148
July 3	.110	.142	.157	.090
23	.179	.194	.194	+0.019
Aug. 12	.231	.227	.213	−0.052
Sept. 1	.260	.237	.211	.116
21	.262	.224	.187	.171
Oct. 11	.237	.186	.143	.206
31	.186	.128	.082	.222
Nov. 20	.118	+0.058	+0.015	.216
Dec. 10	+0.034	−0.022	−0.058	.187
30	−0.052	.098	.123	.141
50	−0.136	−0.168	−0.180	−0.082

Since the above formulas were derived entirely from observations made previous to 1894.0, the comparison with observation since that epoch gives an idea of the accuracy with which predictions can be made. Such a comparison, using a normal observed series of values of $\varphi - \varphi_0$ fifty days apart from 1894.0 to 1896.5, based on the combined observations by Talcott's method at five European stations, gives an average difference without regard to sign of only $\pm 0''.041$; which is sensibly not greater than the uncertainty of the observed points themselves, or than the corresponding quantity, $\pm 0''.035$, for the interval 1889.0 to 1894.0. There can be no reasonable doubt that predictions of the movements of the pole may now be made for several years in advance within the limits of the accuracy with which they can be determined by the most refined methods of observations conducted at a series of stations well adapted for the purpose. An investigation will shortly be printed demonstrating this and several other interesting propositions. Among these, I permit myself to mention here the fact that a discussion of the whole series of observations from 1889 to 1896.5 demonstrates that the radius, r_1, of the 428-day revolution, has been diminishing in accordance with the law of eq. (52) announced in *A.J.* 322, and indeed at a slightly greater rate. It is now only 0″.12, whereas at the beginning of the decade it was 0″.19. I may further say, briefly, that the comparison of the observations at Kasan in 1895 and 1896, in conjunction with those in middle Europe, confirms the fact of the remarkable eccentricity of the annual ellipse, which was developed from the previous European and American observations.

EPHEMERIS OF COMET *f* 1896 (*PERRINE*).

By C. D. PERRINE.

Ephemeris for Greenwich Mean Midnight.

1897	App. α	App. δ	log Δ	Br.
	h m	° ′		
Feb. 1.5	19 48.5	−16 17	0.291	1.8
5.5	48.4	17 45	0.280	2.0
9.5	48.3	19 18		
13.5	48.1	20 57	0.252	2.2
17.5	47.8	22 44		
21.5	47.4	24 41	0.215	2.5
25.5	46.8	26 49		
Mar. 1.5	46.0	29 13	0.170	2.9
5.5	44.8	31 55		
9.5	43.2	35 1	0.114	3.5
13.5	40.5	38 35		
17.5	37.0	42 45	0.050	4.2
21.5	30.8	47 38		
25.5	22.5	53 20	9.982	5.2
29.5	19 7.2	59 57		
Apr. 2.5	18 38.1	67 21	9.917	6.2
6.5	17 31.9	−74 48		

1897	App. α	App. δ	log Δ	Br.
	h m	° ′		
Apr. 10.5	14 50.1	−79 16	9.893	6.2
14.5	11 48.2	75 55		
18.5	10 29.0	68 22	9.914	5.0
22.5	9 55.6	60 26		
26.5	38.9	53 13	9.974	3.4
30.5	29.7	47 0		
May 4.5	24.5	41 45	0.050	2.1
8.5	21.6	37 22		
12.5	9 20.1	−33 51	0.126	1.4

Brightness on Nov. 2 unity.

This ephemeris is based upon my last elements as given in no. 389 of this Journal.

The correction on Dec. 9 was (O−C) :

$$\alpha = +1^s.6 \quad , \quad \delta = +37''$$

While not so reliable as if based on a later orbit, the above ephemeris should be sufficient for finding purposes.

Mt. Hamilton, 1896 *Dec.* 15.

NOTATION OF RECENTLY DISCOVERED VARIABLES.

No.	Star	1900.0 R.A.	1900.0 Decl.	1900 Annual Variation		1855.0 R.A.	1855.0 Decl.	Redness	Magnitudes Max.	Magnitudes Min.
		h m s	° ′	s	′	h m s	° ′			
169	*W Sculptoris*	0 28 15	−33 25.6	+2.96	+0.33	0 26 1	−33 40.5	–	8.5	<10.5
854	*S Horologii*	2 22 22	−60 1.2	1.72	+0.27	2 21 5	−60 13.5	–	9.7	<12.7
2335	*W Geminorum*	6 29 14	+15 24.5	3.44	−0.04	6 26 39	+15 26.3	–	6.8	7.6
2933	*Y Puppis*	8 8 51	−34 50.3	2.29	0.18	8 7 8	−34 42.4	–	8.1	10.0
3244	*S Pyxidis*	9 0 11	−24 41.4	2.64	0.24	8 58 42	−24 30.8	–	8.3	11
3518	*Y Hydrae*	9 46 27	−22 33.0	2.77	0.28	9 44 22	−22 20.4	–	6.5	11?
4056	*RS Centauri*	11 16 6	−61 19.6	2.61	0.33	11 14 9	−61 4.8	–	9.2	<12.9
4481	*U Crucis*	12 26 50	−57 1.7	3.30	0.33	12 24 22	−56 46.8	–	10.3	13.2
4665	*RT Virginis*	12 57 34	+ 5 43.3	3.04	0.32	12 55 18	+ 5 57.9	–	8.8	9.7
5099	*RR Centauri*	14 9 55	−57 23.3	4.19	0.28	14 6 47	−57 10.5	–	7.47	7.81
5796	*RX Scorpii*	16 5 56	−24 38.4	3.61	0.16	16 3 14	−24 31.2	–	9	12
5798	*RU Herculis*	16 6 2	+25 19.8	2.52	0.16	16 4 9	+25 27.0	–	7.0	<10
6160	*RT Herculis*	17 6 47	+27 10.8	2.10	0.08	17 4 58	+27 14.3	–	8.9	<10
6385	*RY Scorpii*	17 44 16	−33 40.5	3.96	−0.02	17 41 18	−33 39.4	–	6.9	8.8
6549	*W Lyrae*	18 11 28	+36 38.1	2.08	+0.02	18 9 54	+36 37.4	–	8.5	12
6686	*U Coronae Austr.*	18 34 17	−37 55.6	4.10	0.05	18 31 12	−37 57.8	–	8.9	<11.8
6724	*V Coronae Austr.*	18 40 41	−38 15.7	4.11	0.06	18 37 36	−38 18.3	–	9	<10.5
6901	*RY Sagittarii*	19 10 2	−33 41.8	3.92	0.10	19 7 4	−33 16.3	–	6.1	<11.3
7538	*RR Capricorni*	20 56 23	−27 29.0	3.57	0.23	20 53 43	−27 39.4	–	9	<10.5
7792	*SS Cygni*	21 38 47	+43 7.6	2.35	0.27	21 37 1	+42 55.4	–	7.2	11.2
8562	*Z Aquarii*	23 47 5	−16 24.7	+3.09	+0.33	23 44 45	−16 39.7	–	8.2	9.3

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Notation of Recently Discovered Variables.

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NOTES ON VARIABLE STARS, — No. 16,

BY HENRY M. PARKHURST.

6900 was recorded upon my star-maps (*American Journal of Science and Arts*, September, 1869), on four dates in 1861, from which the first maximum is estimated. Combining with the maximum given in *A.J.* 339, the period of 485 days' results.

7162 was in the region mapped on five dates in 1861 with the star-mapper, and also in the region mapped on six dates in 1865 with the photo-mapper, recording positions and photometric magnitudes (*American Journal of Science and Arts*, January, 1870). The most plausible period appears to be 218 days.

7260 was in the region mapped on two dates in 1861; neither satisfactory; but probably invisible. The interval is too great to assist in fixing the period.

RESULTS OF OBSERVATIONS.

No.	Star	Phase	Observed Date		E	Corr.	W	Remarks
			Julian	Calendar				
6871	*V Lyrae*	Max.	3819	Sept. 16	3	−12	3	Two equal maxima
"	"	Max.	3851	Oct. 18	3	+20	8	
6888	*RW Sagittarii*	Max.	3796	Aug. 24	–	–	7	PERRY's observations indicate September 1
6892	*RX Sagittarii*	Max.	3777	Aug. 5	–	–	2	Probably earlier
6894	*S Lyrae*	Max.:	3755	July 14	–	–	1	An uncertain intermediate appearance
6900	*W Aquilae*	Max.	0988	July 31	−25	–	1	1861; star-maps. See note above
"	"	Max.	3121	Oct. 19	0	–	9	1894; *A.J.* 339
"	"	Min.	3363:	June 18	1	–	0	1895
"	"	Min.	3848:	Oct. 15	2	–	0	1896
6903	*T Sagittarii*	Max.	3799.9	Aug. 27	1	+31	9	PERRY independently corroborates. Last interval 416 days. Mean period probably about 437 days.
6905	*R Sagittarii*	Max.	3818.5	Sept. 15	41	− 6	9	(—3). Depends upon observation of September 16
6923	*Z Sagittarii*	Min.	3803	Aug. 31	7	–	0	Assumed midway. Period of 452 days indivisible
7118	*X Aquilae*	Max.	3749	July 8	3	+15	6	(—3)
7155	*RR Aquilae*	Max.	3745	July 4	1	−34	6	
7162	*RS Aquilae*	Max.	3762	July 21	–	–	3	See note above
7234	*R Capricorni*	Max.	3840	Oct. 7	39	− 5	5	Correction diminishing
7242	*S Aquilae*	Max.	3839	Oct. 6	77	−10	6	From PARKHURST's observations
"	"	Max.	3842	Oct. 9	77	− 7	3	From PERRY's observations
"	"	Min.	3898	Dec. 4	78	−25	2	" " "
7257	*R Sagittae*	Max.	3866	Nov. 2	191	+ 1	2	Secondary max. From PERRY's observations
7260	*Z Aquilae*	Max.	3774	Aug. 2	5	+ 7	6	
"	"	Min.	3829	Sept. 26	6	–	5	Invisible more than a month. $M—m = 68$
"	"	Max.	3888	Nov. 24	6	− 9	7	The interval suggests a period of 110 days
7261	*R Delphini*	Max.	3858	Oct. 25	40	−37	4	Observations began too late
7351	*RW Cygni*	Min.	3842	Oct. 9	–	–	5	A slow and slight depression, but the only change in seven months
7399	*W Delphini*	Min.	3741.7	June 30	37	− 7	1	I was not aware that it was an *Algol*-variable. Possibly misidentified
7456	*RR Cygni*	Max.	3854	Oct. 21	19	−47	1	Highest point in PERRY's observations
7458	*V Delphini*	Max.	3877	Nov. 13	4	− 5	9	
7468	*T Aquarii*	Max.	3910.0	Dec. 16	63	+ 5	9	Descent twice as rapid as ascent: same as last year

Individual Observations.

Including Observations by ARTHUR C. PERRY.

6871 *V Lyrae.*

Julian	Calendar	Mag.
	1896	
3711.7	May 31	10.8]
3722.6	June 11	13:
3742.6	July 1	12:
3776.6	Aug. 4	11:
3809.6	Sept. 6	10.3
3810.5	7	10.10_2
3813.6	10	10.06_2
3813.6	10	9.9P
3814.6	11	9.9P
3827.5	24	10.20_2
3833.5	30	10.29_2
3842.5	Oct. 9	10.08_2
3859.5	26	10.06_2
3866.5	Nov. 2	10.10_2
3888.5	24	10.73_2
3901.5	Dec. 7	10.8]

6888 *RW Sagittarii.*

Julian	Calendar	Mag.
	1896	
3755.6	July 14	9.5
3775.6	Aug. 3	9.36_2
3777.6	5	8.81
3787.5	15	8.77_2
3787.6	15	9.0P
3789.6	17	8.95_2
3789.7	17	9.1P
3790.6	18	8.49_2
3797.6	25	9.6P
3798.6	26	9.1P
3799.6	27	9.1P
3801.6	29	8.8P
3804.6	Sept. 1	8.4P
3807.5	4	9.12_2
3807.6	4	8.8P
3809.5	6	9.02_2
3809.6	6	9.1P
3810.5	7	9.46_2
3811.6	8	9.23_2
3813.5	10	9.30_2
3813.6	10	9.7P
3814.6	11	9.3P
3819.6	16	9.4P
3829.5	26	9.09_2
3840.5	Oct. 7	9.5
3857.5	24	10.4
3858.5	25	10.5

6892 *RX Sagittarii.*

Julian	Calendar	Mag.
	1896	
3755.6	July 14	9.5
3775.6	Aug. 3	10.23_2
3777.6	5	9.50
3787.5	15	10.70_2
3787.6	15	10.2P
3789.6	17	11.07_2
3789.7	17	10.7P
3797.6	25	11.0P
3799.6	27	11.6P
3801.6	29	11.7P
3804.6	Sept. 1	11.8P

6892 *RX Sagitt.*—Cont.

Julian	Calendar	Mag.
	1896	
3807.5	Sept. 4	12.13
3807.6	4	11.9P
3809.6	6	12.4P
3811.6	8	11.99
3813.6	10	12.3P
3829.5	26	13.2
3840.5	Oct. 7	11]
3857.5	24	11]
3858.5	25	13]

6894 *S Lyrae.*

(Cont. from 365. Comp. Stars 339)

Julian	Calendar	Mag.
	1896	
3711.7	May 31	12.4]
3721.7	June 10	12.8
3741.6	30	12.6
3755.6	July 14	11.6
3777.6	Aug. 4 to	
3918.5	Dec. 24	12.9]
	7 dates	

6900 *W Aquilae.*

(Cont from 339. Comp. Stars 339)

Julian	Calendar	Mag.
	1861	
0983	July 26	9
0984	27	9
0993	Aug. 5	9
1020	Sept. 1	9.5
	1895	
3386.6	July 11	12]
3418.6	Aug. 12	11]
3419.6	13	13:
3449.6	Sept. 12	13:
3478.5	Oct. 11	13:
3510.5	Nov. 12	12.0]
3540.5	Dec. 12	11]
	1896	
3716.6	June 5	11.4
3721.7	10	12.08_2
3741.7	30	11.48
3752.6	July 11	12.1
3814.6	Sept. 11	13.0]
3842.5	Oct. 9	11]

6903 *T Sagittarii.*

(Continued from 365)

Julian	Calendar	Mag.
	1896	
3711.7	May 31	10.8
3712.6	July 1	9.9
3743.7	2	9.9P
3776.6	Aug. 4	8.27_2
3778.6	6	8.02_2
3783.5	11	8.17_2
3787.5	15	7.94_2
3787.6	15	8.3P
3789.6	17	8.00_2
3789.7	17	8.1P
3790.5	18	7.96_2
3797.6	25	7.8P
3799.6	27	7.7P
3801.6	29	8.0P
3804.6	Sept. 1	8.0P

6903 *T Sagitt.*—Cont.

Julian	Calendar	Mag.
	1896	
3807.5	Sept. 4	7.89_2
3807.6	4	8.3P
3809.5	6	7.87_2
3809.6	6	8.2P
3810.5	7	8.22_2
3813.5	10	8.13_2
3813.6	10	8.3P
3814.6	11	8.3P

6905 *R Sagittarii.*

(Continued from 339.)

Julian	Calendar	Mag.
	1896	
3776.6	Aug. 4	8.9
3777.6	5	9.16_2
3783.5	11	9.00_2
3787.5	15	8.55_2
3787.6	15	8.9P
3789.6	17	8.64_2
3789.7	17	8.7P
3790.6	18	8.23_2
3797.6	25	8.2P
3799.6	27	8.2P
3801.6	29	8.3P
3804.6	Sept. 1	7.9P
3807.5	4	8.06_2
3807.6	4	7.8P
3809.5	6	7.96_2
3809.6	6	8.0P
3810.5	7	7.91_2
3813.5	10	7.92_2
3813.6	10	7.8P
3814.5	11	7.18_2
3814.6	11	7.7P
3819.5	16	6.29_2
3819.6	16	7.8P
3820.5	17	7.54
3821.5	18	7.61_2
3823.5	20	7.57_2
3829.5	26	8.40_2

6923 *Z Sagittarii.*

(Cont. from 339. Comp Stars 311)

Julian	Calendar	Mag.
	1896	
3743.6	July 2 to	
3858.5	Oct. 25	13.0]
	5 dates	

7118 *X Aquilae.*

(Cont. from 365. Comp. Stars 339)

Julian	Calendar	Mag.
	1896	
3741.6	June 30	10.58_2
3746.6	July 5	10.56_2
3753.6	12	10.11_2
3755.6	14	10.81_2
3759.6	18	11.22_2

7155 *RR Aquilae*

Julian	Calendar	Mag.
	1896	
3713.7	June 2	11.2
3722.6	11	10.1
3730.6	19	10.49_2
3741.6	30	9.85_2

7155 *RR Aquilae*—Cont.

Julian	Calendar	Mag.
	1896	
3753.7	July 12	9.78_2
3759.6	18	10.28_2
3766.6	25	10.89_2
3774.6	Aug. 2	10.34_2
3780.6	8	10.91_2
3870.5	Nov. 6	13.0]

7162 *RS Aquilae.*

Julian	Calendar	Mag.
	1861	
0992	Aug. 4 to	
1019	31	10.0]
	5 dates	
	1865	
2438	July 20	11.0]
2439	21	11.7:
2441	23	11.0]
2444	26	11.0]
2445	27	11.0]
2448	30	11.0]
	1896	
3716.7	June 5	11.0]
3741.7	30	10.7
3755.6	July 14	10.2
3776.6	Aug. 4	10.4
3777.6	5	10.43_2
3783.6	11	10.71_2
3786.6	14	11.0
3787.6	15	11.30_2
3807.6	Sept. 4	11.84_2
3828.5	25	12.25_2
3841.5	Oct. 8	13.50_2
3859.5	26	13.0]
3871.5	Nov. 7	13.7]

7234 *R Capricorni.*

(Continued from 365)

Julian	Calendar	Mag.
	1896	
3807.5	Sept. 4	13.0]
3829.5	26	11.99_2
3833.6	30	11.59_2
3841.5	Oct. 8	11.77_2
3858.5	25	11.81_2

7242 *S Aquilae.*

Julian	Calendar	Mag.
	1896	
3819.5	Sept. 16	9.9
3827.5	24	9.02_2
3833.5	30	9.23_2
3841.6	Oct. 8	9.3P
3842.5	9	9.15_2
3842.6	9	8.7P
3848.5	15	9.6P
3854.5	21	9.3P
3858.5	25	9.46_2
3859.5	26	9.5P
3862.6	29	9.8P
3866.5	Nov. 2	9.46_2
3866.5	2	9.6P
3870.5	6	10.1P
3873.5	9	9.60_2
3879.5	15	9.57_2

7242 *S Aquilae.*—Cont.

Julian	Calendar	Mag.
	1896	
3886.4	Nov. 22	10.5P
3886.5	22	10.50_2
3895.5	Dec. 1	10.27
3904.5	10	10.5P
3914.5	20	10.6P
3918.5	24	10.1P

7257 *R Sagittae.*

Julian	Calendar	Mag.
	1896	
3841.6	Oct. 8	9.1P
3842.6	9	9.4P
3848.5	15	9.3P
3854.5	21	9.1P
3859.5	26	9.2P
3862.6	29	9.4P
3866.5	Nov. 2	8.6P
3870.5	6	8.7P

7260 *Z Aquilae.*

Julian	Calendar	Mag.
	1861	
0993	Aug. 5	10]:
1021	Sept. 2	10]:
	1896	
3716.6	June 5	12]
3755.6	July 14	9.3
3759.6	18	9.3
3766.6	25	9.73_2
3772.6	31	9.62_2
3775.6	Aug. 3	9.48_2
3778.6	6	9.49_2
3783.6	11	10.97:
3787.6	15	11.03_2
3807.6	Sept. 4	13.1]
3865.5	Nov. 1	11.5
3866.5	2	11.81_2
3867.5	3	11.37_2
3871.5	7	10.73_2
3878.5	14	10.20_2
3880.5	16	9.95_2
3886.5	22	9.80_2
3891.5	27	9.89_2
3895.5	Dec. 1	9.94_2
3901.5	7	10.3

7261 *R Delphini.*

(Continued from 339.)

Julian	Calendar	Mag.
	1896	
3857.5	Oct. 24	8.30_2
3858.5	25	7.81_2
3859.5	26	8.41_2
3864.5	31	8.39_2
3870.5	Nov. 6	8.26_2
3878.5	14	8.60_2
3886.5	22	8.75_2
3895.5	Dec. 1	9.08_2

7351 *RW Cygni.*

Julian	Calendar	Mag.
	1896	
3713.7	June 2	8.8
3722.6	11	8.9
3742.6	July 1	8.6
3755.6	14	8.6

7351 *RW Cygni.*—Cont.

Julian	Calendar 1896	Mag.
3783.6	Aug. 11	9.1
3786.5	14	8.87_2
3789.5	17	9.05_2
3810.6	Sept. 7	9.08_2
3819.5	16	9.03_2
3821.5	18	8.75_2
3823.5	20	8.90_2
3826.5	23	9.14_2
3828.5	25	9.21_2
3841.5	Oct. 8	9.15
3852.5	19	9.23_2
3864.5	31	9.08_2
3874.5	Nov. 10	9.12_2
3880.5	16	8.91_2
3886.5	22	9.03_2
3897.5	Dec. 3	9.13_2

7351 *RW Cygni.*—Cont.

Julian	Calendar 1896-97	Mag.
3907.5	Dec. 13	8.89_2
3919.5	25	8.72_2
3930.5	Jan. 5	9.14_2

7399 *W Delphini.*

Julian	Calendar 1896	Mag.
3712.7	June 1	9.2
3741.7	30	11.0]

7456 *RR Cygni.*

Julian	Calendar 1896	Mag.
3854.5	Oct. 21	8.2P
3857.5	24	8.7P
3866.5	Nov. 2	8.7P
3871.5	7	8.9
3886.5	22	8.7P
3897.5	Dec. 3	8.8

7456 *RR Cygni.*—Cont.

Julian	Calendar 1896	Mag.
3900.4	Dec. 6	8.7P
3904.4	10	8.8P

7458 *V Delphini.*

(Cont. from 372. Comp Stars 311)

Julian	Calendar 1896	Mag.
3712.7	June 1 to	
3829.5	Sept. 26	13]
	5 dates	
3858.5	Oct. 25	9.81_2
3859.5	26	10.11_2
3860.5	27	9.89_2
3862.5	29	9.91_2
3864.5	31	9.90_2
3867.5	Nov. 3	9.40_2
3871.5	7	9.50_2
3878.5	14	9.58_2

7458 *V Delphini.*—Cont.

Julian	Calendar 1896	Mag.
3880.5	Nov. 16	9.48_2
3886.5	22	9.54_2
3895.5	Dec. 1	9.96_2
3901.5	7	10.12_2

7468 *T Aquarii.*

(Continued from 372.)

Julian	Calendar	Mag.
	1895	
3513.5	Nov. 15	7.2P
3515.5	17	7.5P
3517.5	19	7.4P
3527.5	29	8.8P
3533.5	Dec. 5	8.9P
	1896	
3833.6	Sept. 30	11.7P
3857.5	Oct. 24	9.6
3859.6	26	9.7P
3867.5	Nov. 3	9.5

7468 *T Aquarii.*—Cont.

Julian	Calendar 1896	Mag.
3878.5	Nov. 14	9.2
3886.5	22	8.39_2
3891.5	27	8.61_2
3895.4	Dec. 1	8.23_2
3897.4	3	8.11_2
3900.5	6	8.23_2
3901.5	7	7.6P
3904.5	10	8.28_2
3904.5	10	8.0P
3908.5	14	7.93_2
3911.5	17	8.08_2
3914.5	20	8.24_2
3914.5	20	8.0P
3918.5	24	8.5P
3919.5	25	8.57_2
3920.5	26	9.27_2

COMPARISON-STARS.

6871 *V Lyrae.*

Star	DM.	Mag.	n
J	+29°3492	9.14	3
U	+29°3513	9.29	1M
W	+29°3498	9.67	4
1W	+29°3509	9.47	1M
X	+29°3504	9.56	1M
1X	+29°3493	9.91	9
Y	+29°3505	9.69	1M
Z	+29°3494	10.70	8
a	0.9s 5.4p V	10.95	2
b	2.9s 4.2p a	10.97	2
c	3.3n 2.8p a	11.02	2
d	1.7n 1.0p Z	11.05	3
e	3.8n 1.1p V	11.28	2

7155 *RR Aquilae.*

Star	DM.	Mag.	n
Q	−2°5151	8.76	8
1Q	−2°5147	8.72	4
W	−2°5153	9.61	9
b	8.7s 4.7p Q	10.87	2
c	1.4n 2.2p b	11.34	2
d	1.2n 6.9f 1Q	11.49	6
e	5.2s 1.9f V	11.68	2
f	2.0s 4.1p Q	11.96	2
g	0.5n 7.6p V	11.98	2
h	2.5s Q	12.26	1
i	3.5s 0.1p V	12.33	1
j	1.5s 3.1p W	12.37	1
o	1.0n 3.7p g	13.43	1

7260 *Z Aquilae.*

Star	DM.	Mag.	n
F	−6°5111	7.72	1
N	−6°5421	8.53	6
Q	−7°5267	8.37	1
4T	−6°5434	9.73	3
U	−6°5420	9.95	10
2U	−7°5266	9.60	2
W	−6°5417	9.88	11
X	−6°5416	10.78	9
e	1.3n 2.0p V	11.51	6
g	4.2s 0.9p V	11.90	3
h	1.9s 0.7f X	12.12	1
k	3n V	12.60	1
l	1.7p V	12.64	3

7351 *RW Cygni.*

Star	DM.	Mag.	n
F	+39°4221	7.95	4
H	+39°4193	7.52	0M
I	+39°4210	8.06	6
M	+39°4213	8.41	1M
N	+39°4195	8.98	11
P	+39°4217	9.01	6
Q	+40°4163	8.57	0M
R	+39°4206	9.23	22M
S	+39°4209	9.49	10
1S	+39°4230	9.20	3M
3S	+39°4220	9.21	9
T	+40°4224	9.22	3M
W	+39°4223	9.52	6

MAXIMA AND MINIMA OF SHORT-PERIOD VARIABLES, 1895–1896.

By PAUL S. YENDELL.

2279. *T Monocerotis.*

From 1895 Nov. 19 to 1896 April 20 I observed this star thirty-four times. From these observations the following maxima and minima are deduced:

Maxima	w	Minima	w
1895 Nov. 26.1	3	1895 Dec. 14.5	4
Dec. 23.2	1	1896 Feb. 8.4	2
1896 Jan. 19.2	3	Mar. 5.3	2
Mar. 13.5	4	Apr. 2.4	3
Apr. 10.4	4		

4805. *W Virginis.*

My observations of this star, from 1896 April 2 to July 1, number twenty-six. The phases indicated are

Maxima	w	Minimum	w
1896 Apr. 9.2	4	1896 May 4.6	3
May 13.6	4		
29.2	3		

5952. *Y Herculis.*

A series of nineteen observations, from 1896 June 4 to Sept. 1, shows phases as follows:

Maximum	M	Minima	M
1896 June 3	6.9	1896 July 13	8.0
		Aug. 1	8.1

6368. *X Sagittarii.*

Fifteen observations, from 1896 June 29 to Sept. 1. The phases shown by the application of a mean light-curve are

Maxima	obs.	Minima	obs.
1896 July 11.4	1	1896 June 30.9	1
18.8	2	July 14.4	1
29.8	3	Aug. 4.2	2
Aug. 7.1	1	10.4	1
		26.4	1
		Sept. 1.1	1

6472. *W Sagittarii.*

Eighteen observations, from 1896 June 29 to Sept. 1. They yield the following phases by the application of the mean curve:

Maxima	obs.	Minima	obs.
1896 June 29.79	2	1896 July 11.07	1
July 14.20	3	19.34	1
30.91	2	Aug. 2.23	2
Aug. 7.67	3	19.38	1
28.39	2		

6573. *Y Sagittarii.*

Sixteen observations, from 1896 June 29 to Sept. 7. They yield the following phases by the mean curve:

Maxima	obs.	Minima	obs.
1896 July 1.04	2	1896 July 11.41	1
13.49	2	Aug. 3.83	1
31.32	2	8.39:	1
Aug. 29.21	2	26.36	1
		Sept. 6.93	1

6676. *U Sagittarii.*

Twenty-eight observations, from 1896 June 29 to Sept. 11. The following phases are indicated:

Maxima	obs.	Minima	obs.
1896 June 29.75	2	1896 July 10.93	1
July 13.13	2	17.46	2
Aug. 2.27	2	30.75	2
10.36	1	Aug. 12.94	1
16.59	1	21.32	2
29.32	2	27.17	2
Sept. 6.57	1		

6733. *R Scuti.*

Thirty observations, from 1896 June 10 to Nov. 2, indicate a minimum of $7^M.2$ on July 25, and a maximum of $4^M.7$ on August 30.

6854. *Y Aquilae.*

I observed this star during the season of 1895 and 1896, but from the broken character of the series, the results are very meagre. The following phases are pretty certainly indicated:

Maxima	w	Minima	w
1895 Sept. 14.4	3	1895 Sept. 10.3	2
19.3	2	21.3	2
28.3	1	1896 July 10.4	2
1896 July 30.4	2	Aug. 1.4	4
Aug. 8.4	1		

Dorchester, Mass., 1896 *Dec.* 29.

7149. *S Sagittae.*

A series of twenty-eight observations, from 1896 June 2 to Sept. 11, yields five maxima and five minima. Of the maxima, three were of the "flat" type. Both the maxima of the sharply-marked type fall on odd epochs; of the flat maxima, two fall on even epochs, and one on an odd one. This seems to confirm the indications of my earlier observations, that the alternation of these phases is not a regular one.

Maxima		w	Minima	w
1896 July 11.7		4	1896 June 4.4	2
Aug. 5.6	flat	3	30.3	3
14.5	"	3	July 16.8	4
30.9		4	Aug. 2.3	4
Sept. 8.5	flat	3	10.4	4

7257. *R Sagittae.*

I have forty-one observations, from 1896 June 30 to Dec. 24. These indicate maxima and minima as follows:

Maxima	M	w	Minima	M	w
1896 July 24	8.4	4	1896 July 18	9.3	2
Aug. 31	8.7	4	Aug. 13	9.3	4
			Sept. 20	9.6	4

From Sept. 30 to Nov. 9 the star showed little change, remaining during this time about $9^M.1$; two observations of Nov. 24 and Dec. 4 show it at $9^M.6$.

7437. *X Cygni.*

Thirty-two observations, from 1896 May 7 to Sept. 11, show maxima and minimum as follows:

Maxima	w	Minimum	w
1896 June 3.8	3	1896 June 30.2	3
Aug. 7.8	4		
Sept. 8.2	3		

7483. *T Vulpeculae.*

Twenty-eight observations, from 1896 June 2 to Sept. 11, yield maxima and minima as follows, by the application of the mean light-curve:

Maxima	obs.	Minima	obs.
1896 June 1.624	1	1896 June 4.395	1
10.718	1	July 7.906	2
July 11.790	2	14.424	1
29.689	1	17.799	2
Aug. 28.647	1	31.917	2
Sept. 6.863	1	Aug. 4.395	1
11.368	1	9.870	2
		30.779	2

NEW ASTEROIDS.

Prof. Kreutz has communicated the discovery of four new asteroids by Charlois:

	M		h m		h m s	° ′	s ′
DC	13	Dec. 28	10 16.0	Nice M.T.	α = 7 18 24	δ = +26 27	Daily motion, −60 and 3 northward.
DD	13	31	11 31.5	" "	7 50 40	+21 26	" " −48 " 3 "
DE	13	31	11 31.5	" "	7 55 40	+21 41	" " −48 " 0 "
DF	12	31	11 31.5	" "	8 7 4	+23 14	" " −48 " 7 "

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN., WITH A 4½-INCH REFRACTOR,

BY A. W. QUIMBY.

1896	Time	New Grs.	Total		Fac. Grs.	Def.
			Grs.	Spots		
July 1	7	1	3	27	2	fair
2	7	-	2	37	3	fair
3	7	1	3	28	2	fair
4	8	–	2	16	–	v.poor
5	7	–	3	9	–	poor
6	12	2	5	10	2	poor
7	10	–	5	12	2	poor
8	11	–	4	6	1	poor
9	7	–	3	11	1	fair
10	7	–	3	8	1	fair
11	7	1	5	12	2	fair
12	7	1	5	11	2	fair
13	7	2	6	20	3	fair
14	7	2	6	30	4	fair
15	7	–	4	24	3	fair
16	7	–	4	31	3	fair
17	7	–	4	50	3	fair
18	7	–	4	78	3	fair
19	7	1	5	93	3	good
20	7	–	3	32	–	poor
21	3	–	4	28	1	fair
22	12	–	4	31	1	fair
23	7	–	4	30	3	fair
24	4	–	3	30	2	fair
25	7	–	2	29	3	fair
26	7	1	2	13	3	fair
27	7	–	2	10	5	fair
28	7	–	2	13	3	fair
29	7	–	2	13	3	fair
30	7	–	1	12	1	fair
31	7	–	1	10	1	fair
Aug. 1	7	–	1	8	1	fair
2	7	1	2	8	1	fair
3	7	–	2	4	1	fair
*4	7	–	1	2	–	poor
*5	7	–	1	2	–	poor
6	7	–	1	2	4	fair
*7	7	–	0	0	0	poor
8	7	–	0	0	3	fair
9	7	1	1	4	1	fair
10	6	1	1	1	1	fair
11	7	1	2	2	2	good
12	7	2	4	6	3	good
13	7	2	3	5	3	fair
14	7	–	3	7	4	fair
15	7	–	3	28	3	fair
16	7	1	4	27	2	fair
17	7	1	5	39	3	fair
18	7	–	5	18	2	poor
19	7	–	5	17	1	fair
20	7	1	5	11	3	fair
21	7	–	5	14	2	fair
22	12	–	3	20	3	fair
23	2	–	2	32	1	poor
24	7	–	1	38	2	poor
25	7	1	2	24	3	fair
Aug. 26	7	–	2	21	3	fair
27	7	–	2	14	1	fair
28	7	–	2	32	2	good
29	7	–	1	31	3	fair
30	7	2	3	44	2	good
31	7	–	3	18	1	fair
Sept. 1	7	1	4	38	2	good
2	7	–	3	18	3	good
3	7	–	2	17	3	good
4	7		2	11	2	fair
5	7	2	4	9	1	fair
6	7	–	2	5	1	poor
7	7	1	3	22	4	fair
8	7	–	3	44	3	good
9	7	1	4	60	4	good
10	7	–	5	106	3	good
11	7	1	5	162	4	good
12	7	–	3	32	–	poor
13	3	–	3	126	–	poor
14	7	1	4	115	2	fair
16	7	–	1	129	3	fair
17	7	2	3	124	3	fair
18	7	–	3	150	1	fair
19	7	1	3	79	2	poor
20	7	–	3	56	2	poor
21	7	–	4	58	2	fair
*22	9	–	4	18	2	poor
*23	9	–	3	17	–	poor
*24	9	–	3	12	–	poor
25	7	–	2	35	1	fair
26	7	–	1	13	1	poor
27	8	–	1	8	1	fair
29	2	1	2	10	2	fair
30	8	–	2	9	4	fair
Oct. 1	8	–	1	5	2	poor
2	8	1	2	6	2	fair
3	8	–	1	5	2	fair
4	1	–	1	1	1	poor
5	9	–	–	–	1	poor
6	9	1	1	2	1	poor
7	8	–	1	2	3	fair
8	8	1	2	3	3	fair
9	8	–	2	3	3	fair
10	8	1	2	2	3	poor
15	8	–	1	9	–	poor
16	8	2	3	12	1	poor
17	1	2	4	17	3	poor
19	8	–	4	64	4	fair
20	8	–	4	27	3	poor
21	3	–	4	12	2	fair
22	8	–	4	34	1	fair
23	8		4	12	–	poor
24	8	1	5	17	1	fair
25	8	–	5	16	2	good
26	8	–	3	12	2	fair
27	8	–	3	15	3	fair
Oct. 28	8	–	3	19	2	good
29	11	–	1	6	3	poor
30	9	1	2	10	0	poor
31	9	–	2	12	2	fair
Nov. 1	4	–	1	1	–	poor
2	8	1	2	3	3	good
3	10	1	2	5	3	fair
4	8	1	3	7	3	fair
6	8	1	4	6	3	poor
7	8	-	3	10	3	fair
9	11	2	5	32	2	fair
10	8	1	6	35	1	fair
11	8	–	6	24	1	poor
13	8	1	7	33	3	fair
14	8	–	7	32	3	fair
15	8	–	3	18	3	fair
16	8	1	3	28	3	fair
17	8		3	16	4	fair
18	8	–	2	6	1	fair
19	8	–	2	4	1	fair
20	12	1	1	1	1	poor
22	8	1	2	18	2	fair
23	12	–	2	17	2	fair
25	10	1	2	6	1	fair
26	1	–	2	8	0	poor
27	3	–	2	7	–	fair
Dec. 1	3	–	3	15	4	fair
3	8	–	3	22	2	poor
4	8	1	4	31	3	fair
5	8	–	4	42	1	fair
6	9	–	4	33	1	fair
7	9	–	4	15	1	poor
9	8	–	4	23	2	poor
10	8	–	4	22	4	poor
11	8	–	3	12	3	fair
12	11	1	2	12	–	poor
13	8	–	2	10	1	poor
14	8	1	3	19	2	fair
16	3	–	1	4	-	v.poor
17	8	–	2	13	2	fair
18	9	1	3	22	2	fair
19	9	3	5	23	4	poor
20	9	–	3	44	3	fair
21	9	1	4	35	1	fair
22	9	–	3	30	1	poor
23	9	–	2	37	–	poor
24	8	–	1	22	–	fair
25	8	1	3	43	–	fair
26	8	–	1	20	–	poor
27	9	–	3	46	4	fair
28	9	–	3	28	3	fair
29	9	1	3	8	3	poor
30	2	1	3	26	3	fair
31	9	1	4	12	3	fair

* 2⅛-inch refractor, 72 diameter.

OBSERVATIONS OF VARIABLE STARS,—No. 3,

By WM. E. SPERRA.

The arrangement of this and subsequent lists will conform to that of the preceding, to which reference must be made for further information than that afforded by these notes. All of the following maxima and minima fall in the first half of the calendar year 1896.

103. *T Andromedae.*

This star was observed fourteen times, from 1896 May 5 to Aug. 1, and the result is a maximum for 1896 June 26, at $7^{M}.7$. At the beginning and ending of the observations the star was somewhat below the 9th magnitude.

1623. *T Camelopardalis.*

Twelve observations, between 1895 Nov. 12 and 1896 Feb. 17, yield a maximum for 1896 Jan. 6, at $8^{M}.1$. The first observation found the star at $9^{M}.5$, and had again returned at last observation. The fall in light was therefore more rapid than the rise.

1981. *S Camelopardalis.*

Twenty-seven observations of this star, from 1895 Oct. 13 to 1896 May 6, indicate a maximum on 1896 Feb. 11, at $7^{M}.9$. At first observation it was at $9^{M}.5$, it rapidly rose to 9^{M}, at which it stood during November and first few days of December; it then slowly rose to maximum, and by last observation had reached 9^{M}.

2100. *U Orionis.*

I have nineteen observations, between 1896 Feb. 11, when the star was at $7^{M}.5$, and April 22, when the star had fallen to $7^{M}.2$, indicating a maximum for 1896 March 16, at $6^{M}.9$. As so small a portion of the light-curve was observed, less weight must be given it, and especially so because the curve was quite flat at maximum.

2815. *U Geminorum.*

A maximum is indicated for 1896 March 17.2 Gr. M.T., by the five observations following. Magnitude on BAXENDELL's scale, $9^{M}.2$.

	M		M
1896 Mar. 15.52	9.8	1896 Mar. 20.54	9.4
16.62	9.2	23.59	9.9
17.57	9.2		

3493. *R Leonis.*

Fourteen observations, distributed between 1895 Oct. 27 and 1896 Mar. 12, yield as the date of maximum 1896 Jan. 9, at $6^{M}.5$. The observations include the rise from and fall to 8^{M}. For about a month the star was stationary at maximum.

3825. *R Ursae Majoris.*

A maximum of $6^{M}.4$ is indicated for 1896 March 26, by seventeen observations, extending from 1896 Feb. 11 to May 31. The rise was from below 9^{M}, and return to same. The fall immediately after maximum was quite slow; over a month was occupied in falling from $6^{M}.5$ to 7^{M}, while the fall from the latter point to 9^{M} required less than a month.

4826. *R Hydrae.*

Ten naked-eye observations, from 1896 Feb. 11 to May 7, yield as the time of maximum 1896 March 25, at $3^{M}.8$. The rise was from about $5^{M}.8$, and the fall to the same magnitude. The magnitudes are only approximate.

5237. *R Bootis.*

This star was observed nineteen times, between 1896 March 17 to June 10. From $10^{M}.5$, at first date, it rose very rapidly to a maximum of $7^{M}.4$ on 1896 May 5.5, and then fell nearly as rapidly to $9^{M}.5$ at last observation. The maximum was very sharply marked, the fall commencing as soon as the maximum was reached.

2279. *T Monocerotis.*

Seventeen observations of this star, between 1896 Mar. 27 to May 3, yield results as follows in Greenwich Mean Time:

		M
1896 April	1.8	Min. 6.8
	9.5	Max. 5.9
	29.0	Min. 6.8

Randolph, Ohio, 1896 *Dec.* 30.

EPHEMERIS OF ASTEROID (93) *MINERVA*.

By W. S. EICHELBERGER.

I have just finished the computation of the general perturbations of *Minerva* by *Jupiter*, and before publishing I desire to obtain, during the present opposition, as many observations as possible for a better determination of the elements.

It will be a great favor if those who find it possible to observe this asteroid at this time will publish the results at their earliest convenience.

Gr. M.T.	R.A.	Decl.	Δ
	h m s	° ′	
1897 Jan. 12.5	8 39 48	+30 4.5	0.3297
13.5	38 50	7.9	
14.5	37 52	11.2	
15.5	36 53	14.3	
16.5	35 53	17.4	0.3273
17.5	31 53	20.4	
18.5	33 52	23.2	
19.5	8 32 51	+30 26.0	

Gr. M.T.	R.A.	Decl.	Δ
	h m s	° ′	
1897 Jan. 20.5	8 31 49	+30 28.7	0.3259
21.5	30 48	31.2	
22.5	29 46	33.6	
23.5	28 43	36.0	
24.5	27 41	38.1	0.3255
25.5	26 39	40.2	
26.5	25 37	42.1	
27.5	24 35	43.9	
28.5	23 33	45.5	0.3260
29.5	22 31	47.1	
30.5	21 30	48.5	
31.5	20 29	49.7	
Feb. 1.5	19 28	50.8	0.3275
2.5	18 28	51.7	
3.5	17 29	52.6	
4.5	8 16 30	+30 53.2	
1897 Feb. 5.5	8 15 32	+30 53.7	0.3300
6.5	14 35	54.1	
7.5	13 39	54.4	
8.5	12 43	54.4	
9.5	11 48	54.4	0.3333
10.5	10 55	54.2	
11.5	10 2	53.9	
12.5	9 11	53.4	
13.5	8 21	52.8	0.3375
14.3	7 32	52.0	
15.5	6 44	51.1	
16.5	8 5 57	+30 50.1	0.3412

The *Jahrbuch* for 1899 gives the position at opposition,

Berlin M.T.	R.A.	Decl.	Mag.
	h m	° ′	
Jan. 23.5	8 27.3	+30 38	11.5

U.S. Naval Observatory.

ELLIPTIC ELEMENTS AND EPHEMERIS OF COMET *g* 1896 (*PERRINE*),

By W. J. HUSSEY and C. D. PERRINE.

T = 1896 Nov. 24.60 Gr. M.T.
ω = 163° 52′
Ω = 246 30
i = 13 45
q = 1.1112
e = 0.6865

Period, 6.67 years.

EPHEMERIS FOR GREENWICH MIDNIGHT.

1897	α	δ	Brightness
	h m s	° ′	
Jan. 20.5	4 35 44	−0 32	0.18
24.5	48 12	−0 16	
28.5	4 59 52	+0 4	
Feb. 1.5	5 10 52	+0 26	0.10

Communicated by telegraph, Jan. 16, by Dr. E. S. HOLDEN

OBSERVATIONS OF COMET *g* 1896 (*PERRINE*),

MADE AT THE LICK OBSERVATORY WITH THE 12-INCH EQUATORIAL,

By WILLIAM J. HUSSEY.

1896-7 Mt. Hamilton M.T.	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Dec. 9 7 48 8	1	d10 , 10	−0 12.60	−8 38.3	0 58 14.50	+6 4 14.2	8.190	0.659
17 10 3 17	2	d 4	. . .	+7 8.7	. . .	+2 57 18.4	. .	0.698
10 11 35	2	d 7 ,	+0 26.04	. . .	1 54 30.89	. . .	9.390	. .
23 8 8 29	3	10 , 5	+4 18.05	+1 29.6	2 31 59.88	+1 14 12.6	n8.341	0.712
24 7 5 41	4	10 , 6	+3 23.05	+5 3.3	2 37 10.85	+1 0 37.2	n9.179	0.715
Jan. 5 7 4 29	5	d 8 , 8	−0 17.88	−1 50.6	3 39 24.25	−0 38 59.0	n9.257	0.731
5 9 15 40	5	d 8 , 8	+0 5.86	−2 13.2	3 39 47.99	−0 39 21.6	8.910	0.731
6 10 3 31	6	d 8 , 8	+0 3.81	−2 23.3	3 44 20.60	−0 42 28.8	9.240	0.731
8 9 37 54	7	12 , 8	−1 26.67	−4 54.2	3 52 45.01	−0 46 45.3	9.091	0.732

Mean Places for 1896.0 and 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	0 58 22.96	+4.14	+6 12 24.8	+27.7	½ (Schjellerup 356 + Paris 1366)
2	1 54 0.49	+4.36	+2 49 44.6	+25.1	Boss, Albany A.G. Catal. 556
3	2 27 37.32	+4.51	+1 12 19.8	+23.2	Boss, Albany A.G. Catal. 712
4	2 34 13.27	+4.53	+0 55 11.2	+22.7	Schjellerup 746
5	3 39 40.42	+1.71	−0 37 14.2	+ 5.8	Stone, Radcliffe Catal. 878
6	3 44 15.09	+1.70	−0 40 11.4	+ 5.9	Göttingen Catal. 649
7	3 54 9.96	+1.72	−0 41 56.5	+ 5.4	Schjellerup 1240

d indicates that both coordinates have been determined by direct measures with the micrometer.

Mt. Hamilton, Cal., 1897 *Jan.* 8.

OBSERVATIONS OF COMET *g* 1896 (*PERRINE*),

MADE AT THE VASSAR COLLEGE OBSERVATORY.

By MARY W. WHITNEY.

1897 Greenwich M.T.	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log *p*Δ for α	log *p*Δ for δ
			m s	′ ″	h m s	° ′ ″		
Jan. 7 16 19 43	1	9	+0 19.66	+2 19.2	. . .	. . .	. .	. .
8 14 29 7	2	8	−2 0.38	−4 11.4	3 52 11.45	−0 46 32.5	9.035	0.774

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 48 1	. .	−0 47.7	. .	DM. −0°614
2	3 51 10.11	+1.72	−0 41 53.5	+5.4	Bonn VI, 0°626

POLAR CAP OF *MARS*.

Mr. RITCHIE transmits the following dispatch received by him from the Lowell Observatory:— "For code distribution: rift in Martian north polar cap since January seventh, longitude forty." PERCIVAL LOWELL.

NEW ASTRONOMICAL WORKS.

Researches on the Evolution of the Stellar Systems. Vol. I. On the Universality of the Law of Gravitation, and on the Orbits and General Characteristics of Binary Stars. By T. J. J. SEE, A.M. Ph.D., (Berlin).

This work is the first volume of an extensive investigation which Dr. SEE has undertaken on the evolution of our stellar systems. It is dedicated to Dr. GOULD, and the present volume consists of an introduction and three chapters.

The introduction begins with a sketch of the nebular hypothesis of our solar system. Dr. SEE refers to KANT as a predecessor of LAPLACE in this speculation, and it should be stated that KANT refers to THOMAS WRIGHT. Dr. SEE considers the extension of the nebular hypothesis to the stellar systems, and to the theory of tides. He calls attention to the striking characteristics of double-star orbits: 1. The orbits are highly eccentric. 2. The stars of a system are comparable, and frequently almost equal in mass.

In Chapter I the author gives the common proof of the Newtonian law of force for our solar system, and then proceeds to consider the proof for the orbits of binary stars. He gives the investigations of DARBOUX and HALPHEN for the different laws of force. It may be noticed here that the earlier discussion of this question by VILLARCEAU, which our author does not mention, has been shown by HILL to be correct, and as general as the others. Hence the remarks in TISSERAND'S *Mécanique Céleste*, Tome I, p. 42, are unjust. On page 36 a method is proposed for testing the universality of the law of gravitation; and on page 38 the author proposes a method of determining the distances of star clusters, and of the Milky Way. This chapter closes with an outline of the known methods of computing the orbit of a double star, for correcting an approximate orbit, and with a method for solving KEPLER'S problem.

Chapter II, pp. 65–243, contains the orbits of forty binary stars deduced from the best observations. This is the laborious part of the volume, and the work appears to be very well done.

Chapter III, pp. 243–258, presents a discussion of the results. It is pointed out, page 246, that the motions of certain binaries in the line of sight can be measured by the spectroscope. On page 248 the relations of the orbits of binary stars to the plane of the Milky Way are examined, but no definite relation is shown. The mean value of the eccentricity from the forty orbits is 0.48. The relative masses of the components for a few known cases indicate that the masses are nearly equal, and a more general method of investigating this point is proposed. In his closing article the author compares the stellar systems with our planetary system, and points out the great differences between them.

It is to be hoped that Dr. SEE may be able to complete the extensive work he has so well begun. A. H.

Formation Mécanique du Système du Monde, Lt. Colonel R. du LIGONDÈS, *avec un resumé de la nouvelle théorie par* L'ABBÉ TH. MOREUX, *Professeur de Mathématiques.* Paris, 1897. 8°, pp. 183.

This is an examination of the theories of the nebular hypothesis presented a century ago for our solar system by LAPLACE, and those of FAYE in his work, *Sur l'Origine du Monde.* ABBÉ MOREUX has prefixed an exposition of the mechanical formation of the solar system. The conclusion is reached that the planets will finally fall on the sun:—"*Ainsi finiront les mondes.*" Col. LIGONDÈS appears to have developed some new and ingenious theories, and to have made a real addition to the literature of this subject. A. H.

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NEW ASTRONOMICAL WORKS.

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ON THE INTEGRATION OF THE DIFFERENTIAL EQUATIONS OF MOTION IN THE PROBLEM OF TWO BODIES,

By KURT LAVES.

In the sixteenth chapter of his "*Vorlesungen über Dynamik*," C. G. J. Jacobi applies his theorem of the last multiplier, which was developed in a most general way in the preceding chapters, to the problem of two bodies which move in vacuo under the assumption of Newton's law of mutual attraction. The order of this problem being the twelfth, eight of the ten integrals which we know are applied, so that two differential equations of the second order are left, which Jacobi transforms into four differential equations of the first order. From the nature of the force-function in this problem it follows that we may eliminate the time from three of these differential equations by introducing into them the value of dt taken from the fourth. There are left then three differential equations of the first order for which we know two integrals: the principle of *vis viva* and the principle of conservation of areas in the xy-plane. Jacobi shows that from these two integrals we may obtain the integrating factor of the third differential equation. This being accomplished, and three of the dependent variables expressed in terms of the fourth dependent variable, we find this one expressed in function of the time by that quadrature to which the equation of elimination leads which has furnished the value of dt. This is the most logical solution of the problem, since it shows that the possibility of integration depends upon the special character of the force-function. I have attempted in the first part of the following paper to give a condensed representation of Jacobi's method, and to present in the second part a simplification of it which I have not seen given elsewhere, and which might be of some interest to students of theoretical Astronomy.

I. By the principle of conservation of the motion of the center of gravity the problem of two bodies is reduced to the sixth order. Applying furthermore the two integrals which are given by the principle of conservation of areas for the zy and xz-planes, and taking for the xy-plane the plane of the orbit, we have the following differential equations:

$$\frac{d^2x}{dt^2} = -k^2\frac{x}{r^3} \quad , \quad \frac{d^2y}{dt^2} = -k^2\frac{y}{r^3} \tag{1}$$

Introduce x' and y' as new variables by letting

$$x' = \frac{dx}{dt} \;,\; y' = \frac{dy}{dt}$$

and then transform our system (1) into four differential equations of the first order:

$$\left.\begin{aligned} \frac{dx}{dt} &= x' & \qquad \frac{dy}{dt} &= y' \\ \frac{dx'}{dt} &= -k^2\frac{x}{r^3} & \qquad \frac{dy'}{dt} &= -k^2\frac{y}{r^3} \end{aligned}\right\} \tag{2}$$

For this system we know the following two integrals:

$$\left.\begin{aligned} xy' - yx' &= \alpha & & & f_1 &= \alpha \\ \tfrac{1}{2}(x'^2+y'^2) - \frac{k^2}{r} &= \beta & &\text{or} & f_2 &= \beta \end{aligned}\right\} \tag{3}$$

From the first equation in (2) it follows

$$dt = \frac{dx}{x'} \tag{4}$$

introducing this value into the last three equations of (2), we obtain

$$\frac{dy}{dx} = \frac{y'}{x'} \qquad \frac{dx'}{dx} = -k^2\frac{x}{r^3}\cdot\frac{1}{x'} \qquad \frac{dy'}{dx} = -k^2\frac{y}{r^3}\cdot\frac{1}{x'} \tag{5}$$

Let $f_3 = \gamma$ be the third integral which we seek, so that $f_1 = \alpha$ $f_2 = \beta$ $f_3 = \gamma$ will fulfill our system (5). To obtain $f_3 = \gamma$ we have to find the integrating factor for the equation

$$\frac{dy}{dx} = \frac{y'}{x'}$$

Let equations (5) be written in the form of a proportion,

$$dx : dy : dx' : dy' = x' : y' : -\frac{k^2x}{r^3} : -\frac{k^2y}{r^3} \tag{6}$$

Differentiate $f_1 = \alpha \quad f_2 = \beta \quad f_3 = \gamma$ totally

$$(7)\quad \begin{cases} \dfrac{\partial f_1}{\partial x} \,.\, dx + \dfrac{\partial f_1}{\partial y} \,.\, dy + \dfrac{\partial f_1}{\partial x'} \,.\, dx' + \dfrac{\partial f_1}{\partial y'} \,.\, dy' = 0 \\ \dfrac{\partial f_2}{\partial x} \,.\, dx + \dfrac{\partial f_2}{\partial y} \,.\, dy + \dfrac{\partial f_2}{\partial x'} \,.\, dx' + \dfrac{\partial f_2}{\partial y'} \,.\, dy' = 0 \\ \dfrac{\partial f_3}{\partial x} \,.\, dx + \dfrac{\partial f_3}{\partial y} \,.\, dy + \dfrac{\partial f_3}{\partial x'} \,.\, dx' + \dfrac{\partial f_3}{\partial y'} \,.\, dy' = 0 \end{cases}$$

Introduce the following quantities for abbreviation:

$$(8)\quad A = \begin{vmatrix} \dfrac{\partial f_1}{\partial y}, & \dfrac{\partial f_1}{\partial x'}, & \dfrac{\partial f_1}{\partial y'} \\ \dfrac{\partial f_2}{\partial y}, & \dfrac{\partial f_2}{\partial x'}, & \dfrac{\partial f_2}{\partial y'} \\ \dfrac{\partial f_3}{\partial y}, & \dfrac{\partial f_3}{\partial x'}, & \dfrac{\partial f_3}{\partial y'} \end{vmatrix} \qquad B = \begin{vmatrix} \dfrac{\partial f_1}{\partial x'}, & \dfrac{\partial f_1}{\partial y'}, & \dfrac{\partial f_1}{\partial x} \\ \dfrac{\partial f_2}{\partial x'}, & \cdot\,\cdot & \cdot\,\cdot \\ \dfrac{\partial f_3}{\partial x'}, & \cdot\,\cdot & \cdot\,\cdot \end{vmatrix}$$

$$C = \begin{vmatrix} \dfrac{\partial f_1}{\partial y'}, & \dfrac{\partial f_1}{\partial x}, & \dfrac{\partial f_1}{\partial y} \\ \cdot\,\cdot & \cdot\,\cdot & \cdot\,\cdot \\ \cdot\,\cdot & \cdot\,\cdot & \cdot\,\cdot \end{vmatrix} \qquad D = \begin{vmatrix} \dfrac{\partial f_1}{\partial x}, & \dfrac{\partial f_1}{\partial y}, & \dfrac{\partial f_1}{\partial x'} \\ \cdot\,\cdot & \cdot\,\cdot & \cdot\,\cdot \\ \cdot\,\cdot & \cdot\,\cdot & \cdot\,\cdot \end{vmatrix}$$

From (7) we obtain by elimination,

$$dx : dy : dx' : dy' = A : B : C : D.$$

Comparing this with (6) we see that we are allowed to put

$$(9)\quad A = Mx' \quad B = My' \quad C = -M\frac{k^2x}{r^3} \quad D = -M\frac{k^2y}{r^3}$$

But since $\dfrac{\partial^2 f}{\partial x \,.\, \partial y} = \dfrac{\partial^2 f}{\partial y \,.\, \partial x}$, etc., we see that the following equation will hold between the quantities A, B, C, D.

$$\frac{\partial A}{\partial x} + \frac{\partial B}{\partial y} + \frac{\partial C}{\partial x'} + \frac{\partial D}{\partial y'} = 0$$

or, using the values in (9),

$$\frac{\partial(Mx')}{\partial x} + \frac{\partial(My')}{\partial y} + \frac{\partial\left(-M\dfrac{k^2x}{r^3}\right)}{\partial x'} + \frac{\partial\left(-M\dfrac{k^2y}{r^3}\right)}{\partial y'} = 0$$

Developing this partial differential equation we find

$$(10)\qquad x'\frac{\partial M}{\partial x} + y'\frac{\partial M}{\partial y} - \frac{k^2x}{r^3}\,\frac{\partial M}{\partial x'} - \frac{k^2y}{r^3}\,\frac{\partial M}{\partial y'} = 0$$

It is easy to see that $f_1 = \alpha \quad f_2 = \beta \quad f_3 = \gamma$ will fulfill this equation; indeed, take $f_1 = \alpha$ and we obtain

$$x'\frac{\partial f_1}{\partial x} + y'\frac{\partial f_1}{\partial y} - \frac{k^2x}{r^3} \,.\, \frac{\partial f_1}{\partial x'} - \frac{k^2y}{r^3} \,.\, \frac{\partial f_1}{\partial y'} = 0$$

Dividing by x', and using equation (6), we find

$$\frac{\partial f_1}{\partial x}\,dx + \frac{\partial f_1}{\partial y}\,dy + \frac{\partial f_1}{\partial x'}\,dx' + \frac{\partial f_1}{\partial y'}\,dy' = 0 \quad \text{or} \quad df_1 = 0$$

in the same manner are $f_2 = \beta$ and $f_3 = \gamma$ solutions of the partial differential equation above, and since they are supposed to be independent of each other, so will $F(f_1, f_2, f_3)$ be the general solution of (10), where F is an arbitrary function of f_1, f_2, f_3.

Equations (3) establish two relations between x, y, x', y' and α and β; we may, therefore, suppose that x' and y' be expressed by means of $x, y, \alpha, \beta,$ and can regard also f_3 as a function of x, y, α, β. If we consider the determinant A we see that it contains $\dfrac{\partial f_3}{\partial y}, \dfrac{\partial f_3}{\partial x'}, \dfrac{\partial f_3}{\partial y'}$ We must, therefore, replace these values which are taken under the assumption that $f_3 = f_3(x, y, x', y')$ by such values as will agree with $f_3 = f_3(x, y, f_1, f_2)$. To distinguish the partial derivatives made under this second supposition we shall put them in parentheses. Then we obtain

$$\left.\begin{aligned} \frac{\partial f_3}{\partial y} &= \left(\frac{\partial f_3}{\partial y}\right) + \left(\frac{\partial f_3}{\partial f_1}\right)\frac{\partial f_1}{\partial y} + \left(\frac{\partial f_3}{\partial f_2}\right)\frac{\partial f_2}{\partial y} \\ \frac{\partial f_3}{\partial x'} &= \;\cdot\,\cdot\quad \left(\frac{\partial f_3}{\partial f_1}\right)\frac{\partial f_1}{\partial x'} + \left(\frac{\partial f_3}{\partial f_2}\right)\frac{\partial f_2}{\partial x'} \\ \frac{\partial f_3}{\partial y'} &= \;\cdot\,\cdot\quad \left(\frac{\partial f_3}{\partial f_1}\right)\frac{\partial f_1}{\partial y'} + \left(\frac{\partial f_3}{\partial f_2}\right)\frac{\partial f_2}{\partial y'} \end{aligned}\right\} \quad (11)$$

For A we have the value

$$A = \frac{\partial f_3}{\partial y} \,.\, a_{3y} + \frac{\partial f_3}{\partial x'} \,.\, a_{3x'} + \frac{\partial f_3}{\partial y'} \,.\, a_{3y'}$$

where the a_3 quantities are minors of A.

A becomes zero if we make two horizontal lines equal, therefore it follows

$$0 = \frac{\partial f_2}{\partial y} \,.\, a_{3y} + \frac{\partial f_2}{\partial x'} \,.\, a_{3x'} + \frac{\partial f_2}{\partial y'} \,.\, a_{3y'}$$

$$0 = \frac{\partial f_1}{\partial y} \,.\, a_{3y} + \frac{\partial f_1}{\partial x'} \,.\, a_{3x'} + \frac{\partial f_1}{\partial y'} \,.\, a_{3y'}$$

Multiplying the equations in (11) by $a_{3y}, a_{3x'}, a_{3y'}$ and adding, we get

$$A = \left(\frac{\partial f_3}{\partial y}\right) \,.\, a_{3y}$$

This value will enable us to find the integrating factor of our last differential equation. Indeed, we have had in (9) $Mx' = A$ and for M we use the general solution F; then we find

$$F \,.\, x' = \left(\frac{\partial f_3}{\partial y}\right) \,.\, a_{3y} \qquad (12)$$

Calling I the last multiplier which makes the left side of $x'dy - y'dx = 0$ a total differential, we have

$$Ix'dy - Iy'dx = df_3 = \left(\frac{\partial f_3}{\partial y}\right) dy + \left(\frac{\partial f_3}{\partial x}\right) dx = 0 \quad (13)$$

from this equation follows

$$Ix' = \left(\frac{\partial f_3}{\partial y}\right) \quad \text{and} \quad -Iy' = \left(\frac{\partial f_3}{\partial x}\right)$$

Introducing the value of x' from the first of these equations into (12) we obtain $I = \dfrac{F}{a_{3y}}$; substituting this value into (13) we get $\dfrac{1}{a_{3y}}\{x'dy - y'dx\} = \dfrac{df_3}{F}$. Since the values of f_1 and f_2 are known, we may suppose them to be introduced in F so that F will be a function of f_3 alone. $\dfrac{df_3}{F(f_3)}$ is therefore to be regarded as a total differential, and $\frac{1}{a_{3y}}$ is that last multiplier which transforms the left side into this form of a total differential. Since

$$a_{3y} = \begin{vmatrix} \frac{\partial f_1}{\partial x'}, & \frac{\partial f_1}{\partial y'} \\ \frac{\partial f_2}{\partial x'}, & \frac{\partial f_2}{\partial y'} \end{vmatrix}$$

is a function of quantities which we know, so far as equations (5) are concerned, it follows that our problem is solved.

$f_1 = \alpha \quad f_2 = \beta \quad f_3 = \gamma$ will give the values of y', x', y in function of x, and introducing the value of x' into $dt = \frac{dx}{x'}$, the relation between x and the time will be given by a quadrature. By this we obtain all of the variables expressed in function of the time, and so our problem is solved.

Applying the theory of the last multiplier just outlined to our equations (5) we must find first the value of $\frac{1}{a_{3y}}$ from (3) we obtain

$$\frac{\partial f_2}{\partial x'} = x' \qquad \frac{\partial f_2}{\partial y'} = y'$$
$$\frac{\partial f_1}{\partial x'} = -y \qquad \frac{\partial f_1}{\partial y'} = x$$

$$\therefore \frac{1}{a_{3y}} = \frac{1}{xx'+yy'}$$

Solving the equations (3) with respect to x' and y' we find

$$(14) \qquad \begin{cases} x' = \frac{1}{r^2}\left\{ -\alpha y + x\sqrt{2r^2\beta+2rk^2-\alpha^2} \right\} \\ y' = \frac{1}{r^2}\left\{ \alpha x + y\sqrt{2r^2\beta+2rk^2-\alpha^2} \right\} \end{cases}$$

with these values we obtain for

$$\frac{x'dy-y'dx}{xx'+yy'} = -\alpha\frac{(xdx+ydy)}{r^2\sqrt{2r^2\beta+2rk^2-\alpha^2}} + \frac{xdy-ydx}{r^2}$$
$$= -\alpha\frac{dr}{r\sqrt{2r^2\beta+2rk^2-\alpha^2}} + \frac{d\left(\frac{y}{x}\right)}{1+\left(\frac{y}{x}\right)^2}$$

by integration we obtain

$$(15) \qquad -\alpha\int\frac{dr}{r\sqrt{2r^2\beta+2rk^2-\alpha^2}} + \operatorname{arc} tg\left(\frac{y}{x}\right) = \gamma$$

Since $r^2 = x^2+y^2$, equation (15) will establish the last relation between x and y. If we therefore introduce the value of y into (14) we shall have x', y', y expressed in function of x and the constants of integration α, β, γ. Put the value of x' thus obtained into $dt = \frac{dx}{x'}$ and we shall get

$$t = \int\frac{dx}{x'} + \delta \qquad \text{or} \qquad x = q_1(t, \delta)$$

The last value of x combined with those values of y, x', y' mentioned above will give us

$$x = q_1(t; \delta)$$
$$y = q_2(t; \delta, \gamma)$$
$$x' = q_3(t; \delta, \gamma, \beta, \alpha)$$
$$y' = q_4(t; \delta, \gamma, \beta, \alpha)$$

the finite integral equations of our problem.

II. It is somewhat laborious to carry out the last steps indicated in I, and since it requires the introduction of the polar coordinates r and v into our problem, I have thought it might be advisable to start from the very beginning of our problem with the polar coordinates. This indeed proved to shorten the entire method considerably.

Introduce $x = r\cos v$, $y = r\sin v$, into equations (1):

$$\frac{d^2r}{dt^2}\sin v + \frac{d^2v}{dt^2}\cdot r\cos v + 2\frac{dr}{dt}\cdot\frac{dv}{dt}\cos v - \left(\frac{dv}{dt}\right)r^2\sin v = -\frac{k^2}{r^2}\sin v$$

$$\frac{d^2r}{dt^2}\cos v - \frac{d^2v}{dt^2}\cdot r\sin v - 2\frac{dr}{dt}\cdot\frac{dv}{dt}\sin v - \left(\frac{dv}{dt}\right)r^2\cos v = -\frac{k^2}{r^2}\cos v$$

From these equations we derive the following ones:

$$\left.\begin{aligned} \frac{d^2r}{dt^2} - \left(\frac{dv}{dt}\right)^2\cdot r &= -\frac{k^2}{r^2} \\ r\frac{d^2v}{dt^2} + 2\frac{dr}{dt}\cdot\frac{dv}{dt} &= 0 \end{aligned}\right\} \quad (a)$$

We write the second equation in (a) in the following form:

$$\frac{1}{r}\frac{d}{dt}\left(r^2\frac{dv}{dt}\right) = 0$$

We can integrate this equation at once and obtain

$$r^2\frac{dv}{dt} = \alpha \quad \text{(see equation 3)}$$

If we introduce this value of $\frac{dv}{dt}$ into the first equation (a) we can reduce system (a), which is of the fourth order, to one of third order.

$$\frac{dv}{dt} = \frac{\alpha}{r^2} \qquad \frac{d^2r}{dt^2} = -\frac{k^2}{r^2} + \frac{\alpha^2}{r^3} \qquad (b)$$

We replace the second differential equation in (b) by two differential equations where each one is of the first order by introducing $r' = \frac{dr}{dt}$. Then we have

$$\frac{dv}{dt} = \frac{\alpha}{r^2} \qquad \frac{dr}{dt} = r' \qquad \frac{dr'}{dt} = \frac{1}{r^2}\left\{\frac{\alpha^2}{r} - k^2\right\} \qquad (c)$$

Eliminating the independent variable t by the equation $dt = \frac{dr}{r'}$, we are led to a quadrature, after r' has been found as a function of r. We have, therefore, to integrate the following *two* differential equations:

$$\frac{dv}{dr} = \frac{\alpha}{r'\cdot r^2} \qquad \frac{dr'}{dr} = \frac{1}{r'\cdot r^2}\left\{\frac{\alpha^2}{r} - k^2\right\} \qquad (d)$$

For this system of differential equations we know one integral, namely, that of *vis viva*, which we can derive directly from the second equation in (*d*) which presents itself in the following form:

$$(e) \qquad r'dr' = \frac{dr}{r^2}\left\{\frac{\alpha^2}{r} - k^2\right\}$$

When integrated, we obtain

$$\tfrac{1}{2}\, r'^2 = -\frac{\alpha^2}{2r^2} + \frac{k^2}{r} + \beta \quad \text{or} \quad f_2 = \beta$$

and we find

$$r' = \frac{1}{r}\sqrt{2\beta r^2 + 2k^2 r - \alpha^2}$$

To find the integrating factor of the first equation in (*d*) we need not refer to the theory of the last multiplier, since this last equation can be integrated at once. After we have introduced the value of r' from above, we obtain

$$v - \alpha \int \frac{dr}{r\sqrt{2r^2\beta + 2rk^2 - \alpha^2}} = \gamma \quad \text{(see equation 15)} \qquad (f)$$

The relation between t and r is given by

$$t = \int \frac{r\,dr}{\sqrt{2\beta r^2 + 2k^2 r - \alpha^2}} + \delta_1 \qquad (g)$$

The University of Chicago, 1897 *Jan.* 17.

OBSERVATIONS OF THE COMPANION TO *PROCYON* AND OF THE COMPANION TO *SIRIUS*,

By J. M. SCHAEBERLE.

It is now eight weeks since the announcement of the discovery at this Observatory of the companion of *Procyon*. Up to the time of this writing, however, no information has been received as to whether the companion has been seen at any other observatory. I therefore give at this time all the measures I have been able to make with the 36-inch refractor.

MEASURES OF THE COMPANION TO *Procyon*.

Date	Position-Angle	Distance	Weight
1896	°	″	
Nov. 13	318.8	4.58	3
14	320.4	4.58	2
Dec. 19	319.3	4.89	1
1897 Jan. 10	322.3	4.62	3

The nights of Nov. 13 and Jan. 10 were both superb so far as the seeing was concerned, and, from an inspection of the individual measures on each night, I feel quite persuaded that the change in the position-angle as shown by the measures indicates the *direction* of orbital motion.

MEASURES OF THE COMPANION TO *Sirius*.

The first observation of the companion to *Sirius* since its periastron passage, was made by Prof. AITKEN, of this Observatory, on Oct. 25, 1896. His first measures, together with two of my own, were published in no. 388 of this *Journal*.

Up to the time of this writing no observations have been received from any other observatory. (It is proper to state here that, in our 36-inch telescope, there is no star visible in the place published by Dr. SEE of the Lowell Observatory.) All my own observations up to date are as follows:

Date	Position-Angle	Distance	Weight
1896	°	″	
Oct. 28	188.3	3.65	1
30	190.0	3.65	3
Nov. 6	188.3	3.85	3
1897 Jan. 10	189.4	3.72	5

When the seeing is best the companion is as easily observed and measured as *Phobos* when *Mars* is in opposition. For the same character of seeing the companion to *Procyon* is as readily measured as *Phobos* when the latter is about 10″ from the limb of *Mars* at opposition. It is useless to look for either of these companions with the 36-inch telescope when the seeing is not good.

Lick Observatory, University of California, 1897 *Jan.* 11.

MEASURES OF *PROCYON*,

MADE WITH THE 36-INCH EQUATORIAL OF THE LICK OBSERVATORY,

By R. G. AITKEN.

I have been able to secure two measures of the companion to *Procyon* discovered by Prof. SCHAEBERLE. Each measure of position-angle is the mean of four settings, and each distance the mean of three double distances. On both nights *Procyon* was within an hour of the meridian.

	θ	ρ	Power	Seeing
	°	″		
1896.921	324.1	4.73	520	3+
1896.973	320.1	5.08	520	3
1896.95	322.1	4.90		

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE VASSAR COLLEGE OBSERVATORY, POUGHKEEPSIE, N. Y.,

By Prof. MARY W. WHITNEY and CAROLINE E. FURNESS.

1896 Greenwich M.T.	*	No. Comp.	Planet — *		Planet's apparent		log $p\Delta$		Obs.
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ	
			(106) *Dione.*						
Sept. 25 13ʰ 23ᵐ 34ˢ	1	5	+3ᵐ 57ˢ.00	+ 4′ 15″.8	23ʰ 47ᵐ 26ˢ.34	− 8° 38′ 46″.1	*n*9.495	0.813	W
26 13 51 44	1	8	+3 11.33	+ 0 45.1	23 46 40.68	− 8 42 16.8	*n*9.422	0.819	W
			(225) *Henrietta.*						
Oct. 7 14 58 36	2	10	−0 42.57	+ 9 44.4	23 53 22.48	+ 8 6 29.9	*n*9.903	0.688	F
9 15 12 12	3	8	−0 6.38	− 7 41.8	23 52 21.87	+ 7 42 44.8	*n*8.563	0.692	W
10 14 20 58	4	8	−0 43.02	− 2 36.8	23 51 55.25	+ 7 31 40.9	*n*9.101	0.690	W
			(306) *Unitas.*						
Oct. 15 15 36 50	5	8	+0 17.50	+ 3 37.1	2 2 7.96	− 0 4 30.3	*n*9.271	0.768	W
24 15 3 31	6	5	+0 52.33	− 6 41.5	1 53 44.97	− 1 1 30.5	*n*9.226	0.774	F
27 15 42 24	7	7	−4 22.13	+ 6 19.9	1 50 58.91	− 1 17 22.0	*n*8.841	0.778	F
			(209) *Dido.*						
Nov. 2 15 35 24	9	7	+1 36.22	− 4 9.8	2 40 39.88	+22 51 59.2	*n*9.154	0.468	W
3 14 17 28	9	8	+0 47.20	− 6 35.9	2 39 50.87	+22 49 33.2	*n*9.446	0.520	W
6 15 53 47	10	8	+3 24.59	− 1 21.1	2 37 12.54	+22 41 44.5	*n*8.817	0.458	W
7 13 55 29	10	9	+2 36.94	− 3 46.8	2 36 24.90	+22 39 18.8	*n*9.450	0.748	F
			(354) 1893 *A*						
Nov. 6 17 6 0	11	8	+0 41.62	+10 57.2	3 16 33.50	−10 31 45.1	7.465	0.842	W
11 13 22 12	12	7	−0 38.22	− 0 39.0	3 12 24.78	−10 49 36.3	*n*9.535	0.816	W
			(258) *Tyche.*						
Dec. 1 16 28 40	13	8	+0 34.31	+ 1 50.8	5 37 1.28	+ 4 58 11.2	*n*9.170	0.724	W
3 17 13 59	14	11	+0 0.65	−11 8.9	5 35 5.04	+ 4 46 5.7	*n*8.639	0.723	W
5 15 1 30	15	9	−0 27.73	− 2 21.0	5 34 15.22	+ 4 35 37.8	*n*9.422	0.730	W
11 16 8 2	16	8	+1 17.44	− 7 3.9	5 27 19.69	+ 4 7 21.1	*n*8.976	0.730	W

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	23ʰ 43ᵐ 25ˢ.13	+4ˢ.21 +4.22	− 8° 43′ 27″.6	+25″.7	Weisse's Bessel XXIII, 847
2	23 54 0.97	+4.08	+ 7 56 17.9	+27.6	Bonn VI; DM. 7°5110
3	23 52 24.17	+4.08	+ 7 49 58.9	+27.7	½(Glasgow (1) + Glasgow (2))
4	23 52 34.18	+4.09	+ 7 33 50.0	+27.7	Bonn VI; DM. 7°5106
5	2 1 46.16	+4.30	− 0 8 35.8	+28.4	½(Schur, Göttingen + Copeland and Börgen)
6	1 52 48.29	+4.35	− 0 55 17.0	+28.0	Bonn VI; DM. −1°266
7	1 55 16.65	+4.39	− 1 24 39.8	+27.9	Bonn VI; DM. −1°273
9	2 38 58.88	+4.78 +4.79	+22 55 42.4	+26.6 +26.7	Becker, Berlin A.G. Catal. 821
10	2 33 43.15	+4.80 +4.81	+22 42 38.4	+27.2	½(Paris 3278 + Bonn VI)
11	3 15 47.50	+4.38	−10 43 6.9	+24.6	Weisse's Bessel III, 250
12	3 12 58.54	+4.46	−10 49 21.4	+24.1	½(Paris 3945 + Radcliffe (1890) 779)
13	5 36 22.07	+4.90	+ 4 56 9.3	+11.1	Boss, Albany A.G. Catal. 1851
14	5 34 59.45	+4.94	+ 4 57 3.7	+10.9	" " " " 1842
15	5 34 37.98	+4.97	+ 4 37 48.0	+10.8	" " " " 1833
16	5 25 57.19	+5.06	+ 4 14 14.9	+10.1	" " " " 1780

OBSERVATIONS OF COMET *f* 1896 (*PERRINE*),

MADE AT THE LICK OBSERVATORY WITH THE 12-INCH EQUATORIAL,

BY WILLIAM J. HUSSEY.

1896 Mt. Hamilton M.T.	✱	No. Comp.	☄ − ✱		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
Nov. 2 11h 34m 7s	1	6	. . .	+4′ 45″.2	. . .	+25° 5′ 44″.4	. .	0.690
11 46 33	1	d8	+0m 16s.26	. . .	20h 21m 32s.64	. . .	9.712	. .
3 8 5 14	2	12 , 6	+2 35.67	−3 29.7	20 19 59.25	+24 22 59.5	9.520	0.423
5 7 41 5	3	d8 , 8	+0 19.69	−1 33.4	20 16 35.06	+22 45 43.0	9.491	0.166
6 8 43 16	4	d8 , 8	+0 35.11	+2 13.5	20 14 56.50	+21 55 47.9	9.610	0.530
11 7 55 39	5	d8 , 8	+0 23.54	+5 33.7	20 8 4.43	+18 9 24.5	9.567	0.557
12 8 13 18	6	d8 , 8	+0 1.71	+1 16.2	20 6 52.83	+17 25 39.6	9.570	0.578
Dec. 1 7 56 18	8	18 , 8	−0 52.48	−2 33.6	19 52 3.04	+ 4 36 56.1	9.657	0.712

Mean Places for 1896.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
1	20h 21m 14s.09	+2s.29	+25° 0′ 39″.5	+19″.7	Becker, Berlin A.G. Catal. 7697
2	20 17 21.32	+2.26	+24 26 10.1	+19.1	Becker, Berlin A.G. Catal. 7661
3	20 16 13.09	+2.28	+22 46 57.9	+18.5	Becker, Berlin A.G. Catal. 7648
4	20 14 19.11	+2.28	+21 53 16.3	+18.1	Becker, Berlin A.G. Catal. 7631
5	20 7 38.59	+2.30	+18 3 34.7	+16.1	Auwers, Berlin A.G. Catal. 8019
6	20 6 48.81	+2.31	+17 24 7.4	+16.0	$10\frac{1}{2}^{M}$ ± connected with ✱ 7
7	20 9 23.59	+2.31	+17 29 0.9	+16.0	Auwers, Berlin A.G. Catal. 8044
8	19 52 53.14	+2.38	+ 4 39 21.1	+ 8.6	Boss, Albany A.G. Catal. 6924

d denotes that Δα was measured directly with the micrometer.

Mt. Hamilton, Cal., 1897 *Jan.* 7.

ELLIPTIC ELEMENTS AND EPHEMERIS OF COMET *g* 1896 (*PERRINE*),*

BY W. J. HUSSEY AND C. D. PERRINE.

From Mt. Hamilton observations of Dec. 8, 20 and Jan. 5, we have computed the following elliptic elements of this comet.

Epoch 1896 Dec. 8.5 Gr. M.T.

$$
\begin{array}{rcl}
M & = & 2^{\circ}\ \ 3'\ \ 9''.5 \\
\left.\begin{array}{rcl}
\Omega & = & 246\ \ 30\ \ 22\ .1 \\
\omega & = & 163\ \ 51\ \ 41\ .5 \\
\pi & = & 50\ \ 22\ \ \ 3\ .6 \\
i & = & 13\ \ 45\ \ 19\ .7
\end{array}\right\} & & 1897.0 \\
\log e & = & 9.836649 \\
\log a & = & 0.549565 \\
\log \mu & = & 2.725660
\end{array}
$$

Period, 6.67 years

CONSTANTS FOR THE EQUATOR, 1897.0

$$x = r[9.989420] \sin(v + 139^{\circ}\ 45'\ \ 7''.3)$$
$$y = r[9.979576] \sin(v + \ 45\ \ 43\ \ 41.5)$$
$$z = r[9.568872] \sin(v + \ 83\ \ 48\ \ 39.4)$$

With the exception of ω or π these elements closely resemble those of BIELA's comet at its last apparition in 1852.

EPHEMERIS FOR GREENWICH MIDNIGHT.

1897	App. α	App. δ	log r	log Δ	Br.
Jan 28.5	4h 59m 53s	+0° 3′ 56″	0.146	9.782	0.12
29.5	5 2 41	9 17			
30.5	5 27	14 46	0.150		
31.5	8 11	20 23			
Feb. 1.5	10 52	26 8	0.155	9.812	0.10
2.5	13 31	31 59			
3.5	16 8	37 56	0.160		
4.5	18 43	43 57			
5.5	21 17	50 1	0.164		
6.5	23 49	56 9			
7.5	26 19	1 2 19	0.169	9.858	0.08
8.5	28 47	8 31			
9.5	31 14	14 46	0.174		
10.5	33 40	21 1			
11.5	5 36 1	+1 27 16	0.178	9.887	0.07

Brightness on Dec. 8, unity. Correction to ephemeris 1897 January 20.6:

O − C, in α +5s , in δ +17″

Lick Observatory, University of California, 1897 *Jan.* 14.

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* Already printed in no. 393, p. 71, as communicated by telegraph. — ED.

POSITIONS OF SOME NEW VARIABLES, AND NEIGHBORING COMPANIONS FOR IDENTIFICATION,

BY J. A. PARKHURST.

The following positions were measured with the filar micrometer attached to the 6.2-inch reflector. For the catalogue places of the stars on which the positions depend, I wish to thank Dr. S. C. CHANDLER, Prof. GEO. C. COMSTOCK and Dr. L. DE BALL.

2013. *U Aurigae.*

Comparisons with DM. $+31°1058$ (Leyden Astron. Gesell. Zones), give the place,

$$\begin{array}{lrl}\text{R.A.} = 5^{h}\,32^{m}\,42^{s}.9\ , & \text{Decl.} = +31^{\circ}\,57'\,45'' & (1855)\\ \phantom{\text{R.A.} = 5^{h}\,}34\ \ 1.0 & 58\ \ 31 & (1875)\\ \phantom{\text{R.A.} = 5^{h}\,}35\ \ 38.5 & 59\ \ 26 & (1900)\end{array}$$

11^{M} foll. $3^{s}.6$, $0'.9$ N ; $10^{M}.8$ foll. $11^{s}.5$, $1'.1$ S.

7155. *RR Aquilae.*

The place of this star depends on S.DM. $-2°5151$, which is Lalande 38013, and Münich 22369; also S.DM. $-2°5153$, which is Schjellerup 7706. I find

$$\begin{array}{lrl}\text{R.A.} = 19^{h}\,50^{m}\,4^{s}.5\ , & \text{Decl.} = -2^{\circ}\,16'\,8'' & (1855)\\ \phantom{\text{R.A.} = 19^{h}\,}52\ \ 24.8\ , & 9\ \ 7 & (1900)\end{array}$$

$12^{M}.0$ prec. $0^{s}.3$, $3'.5$ S. ; $11^{M}.8$ prec. $30^{s}.7$, $0'.5$ N.

7162. *RS Aquilae.*

This depends on the place of S.DM. $-8°5186$, from DE BALL's unpublished Astron. Gesell. Catalogue.

$$\begin{array}{lrl}\text{R.A.} = 19^{h}\,51^{m}\,17^{s}.0\ , & \text{Decl.} = -8^{\circ}\,16'\,20'' & (1855)\\ \phantom{\text{R.A.} = 19^{h}\,}53\ \ 43.0 & 9\ \ 15 & (1900)\end{array}$$

12^{M} foll. 8^{s} , $0'.2$ N. ; 12^{M} prec. 13^{s} , $0'.1$ N.

OBSERVED MAXIMA AND MINIMA OF VARIABLE STARS,

BY PAUL S. YENDELL.

419. *U Andromedae.*

Ten observations of this star, from 1896 October 31 to December 23, indicate, rather uncertainly, a maximum on November 27. Its light at the first observation was estimated at 11^{M}, and at the last about $10\frac{1}{2}^{M}$. The highest light observed was about $9^{M}.5$.

845. *R Ceti.*

I observed this star thirteen times, from 1896 October 30 to 1897 January 6. From $9^{M}.5$ at the first observation, it rose to a well-defined maximum of $8^{M}.1$ on December 9, and at the last observation had decreased to $9^{M}.2$.

980. *V Persei.*

Eleven observations, from 1896 September 20 to December 31, indicate pretty definitely a minimum of $10^{M}.3$ on October 25. At the first date its magnitude was estimated as $9^{M}.7$, and when last observed it had risen to $9^{M}.3$.

1113. *U Arietis.*

Thirteen observations of *U Arietis*, from 1896 October 6 to 1897 January 23, indicate a maximum of $8^{M}.2$ on November 12. It was $9^{M}.3$ at the beginning of the series, and $9^{M}.9$ at its end.

1805. *V Orionis.*

I have ten observations of *V Orionis*, from 1896 December 1, when its brightness was estimated at $9^{M}.3$, to 1897 January 23, when it had fallen to $9^{M}.4$. The observations indicate, very definitely, a maximum of $8^{M}.4$ on 1896 December 27.

5601. *S Ursae Minoris.*

I have a series of eighteen observations of this star, from 1896 August 25 to 1897 January 23. A maximum of about $7^{M}.8$ is very sharply indicated on 1896 December 8, and at the last observation the star had decreased to $8^{M}.7$.

7450. *V Aquarii.*

Twenty-one observations of *V Aquarii*, from 1896 June 30 to December 27, indicate a decrease from $8^{M}.7$ to a well-defined minimum of $10^{M}.2$ on October 24. At the last observation the star had increased to $8^{M}.9$.

7458. *V Delphini.*

I have secured eighteen observations of this star, from 1896 October 26 to December 31. At the first observation its brightness was $9^{M}.8$. It rose rapidly to a maximum of $9^{M}.0$, which is indicated on November 14. At the last observation it had decreased to $9^{M}.5$.

7560. *R Vulpeculae.*

Ten observations, from 1896 October 8 to December 1, indicate a well-defined maximum of $8^{M}.0$ on November 3. The star's light at the first and last observations was $9^{M}.6$.

Dorchester, Mass., 1897 *Jan.* 19.

ON ANDERSON'S NEW VARIABLE IN *ANDROMEDA*,

(1855) $0^{h}\ 42^{m}\ 13^{s}$. $+34°\ 51'.8$.

BY J. A. PARKHURST.

Looking for ANDERSON's new variable in *Andromeda* (see *A.N.* 3391), on the evening of Jan. 19, I found a star near the place, fainter than 11^{M}, but probably not much brighter than 12^{M}, although I could not judge very accurately in the moonlight. I measured its position relative to Bonn VI, 34°126, with the result:

$$\text{R.A.} = 0^{h}\ 42^{m}\ 13^{s}.2\quad,\quad \text{Decl.} = +34°\ 51'\ 46''\quad(1855)$$
$$44\ \ 39.4\qquad\qquad\qquad 35\ \ \ 6\ \ 32\quad(1900)$$

There is a 12^{M} star 15^{s} following, $1'.4$ north, but no other star as bright as 12^{M} in the neighborhood. Although this single observation does not identify the variable beyond a doubt, yet it sets an upper limit to its brightness, and makes it seem probable that the new variable changes very rapidly.

Marengo, Ill., 1897 *Jan.* 21.

NEW ASTRONOMICAL WORKS.

Osservazioni Astronomiche e Fisiche sull 'asse di rotazione e sulla topografia del planeta Marte: Memoria Quarta; G.V. SCHIAPARELLI. Rome, 1896.

This is the fourth memoir of a series, all bearing the same title. The first three were devoted to the oppositions of 1877, 1879–80 and 1881–82. The present one contains the discussion of the observations, made with the same instrument, the Merz 8-inch equatorial, during the opposition of 1883–84. Chap. I contains the determination of the position of the rotation-axis from the observations of the northern polar spot; and a comparison of the results with the analogous determination by Dr. LOHSE at Potsdam during the same opposition. Chap. II describes the topographic details observed on various portions of the planet's disk; and Chap. III presents a comparative study of the phenomena of the northern polar cap, and of the gemination of the canals, at the oppositions of 1881–82 and 1884. Among the peculiarities with regard to the latter phenomenon remarked by SCHIAPARELLI may be mentioned the tendency of the duplication to follow the direction of some other canal which has its focus in the same lake, and the fact, still more odd and interesting, that the gemination seen at one opposition in one of the influent canals, follows in another opposition a canal running in a different direction. The interpretation of these singular observations must await the revelation of the nature of the geminations and the mysterious cause which produces them. C.

Annalen der Kaiserlichen Universitäts-Sternwarte in Strassburg. Erster Band. E. BECKER.

The Strassburg Observatory was founded in 1872 by the Emperor Wilhelm I, upon a scale of very great liberality. The buildings and observing arrangements, devised by WINNECKE, marked something of an epoch in observatory construction; and they elicited warm expressions of admiration from the members of the *Astronomische Gesellschaft* who gathered at the Strassburg meeting in 1881 to inspect the completed work. The new observatory experienced a heavy calamity in the illness, in 1882, of its first director, WINNECKE, who was incapacitated for duty from that time, and who was compelled to resign in 1886.

Dr. E. BECKER was appointed director in 1887, and while engaged in important current work of the observatory has labored assiduously to bring up arrears of computation and publication. The present volume, containing the results of observations with the Repsold Meridian Circle from 1882 to Sept. 9, 1886, is the first of the Annals of the Strassburg Observatory; and this is to be followed shortly by the second volume, which is to contain the continuation of the Meridian Circle results to the end of the first series of observations, in the spring of 1888. This series embraced a variety of observations, chiefly those upon the Sun and major planets, upon the 306 stars selected as standards for the southern zones of the *Astronomische Gesellschaft*, and absolute determinations of the declinations of the principal stars. The present volume contains a brief description of the observatory, and of the work with the Meridian Circle. The discussion of the instrument, to ascertain the form of pivots, the flexure, the errors of graduation (for every 5°), and other instrumental constants, is given in full detail. The author points out the want of homogeneity in the work due to the successive engagement upon it of a large number of observers, some of whom had previously possessed but little experience in this class of observations. Inspection of the work, however, leads to the conviction that these results will prove to possess a high value for the purposes intended. L. B.

CORRIGENDA.

No. 392, p. 61, line 6 from below, *for* $9^{s}.27$ and $16''.9$ *put* $5^{s}.70$ and $11''.6$.

" " p. 62, in observations of 1896 Oct. 29 and 30, the first time corresponds to position-angle, the second to distance.

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ON THE VALUES OF THE ECCENTRICITIES AND LONGITUDES OF THE PERIHELIA OF *JUPITER* AND *SATURN* FOR DISTANT EPOCHS.

By G. W. Hill.

The values of these elements derived from the formulas given by LeVerrier and Stockwell, in their general treatment of the secular variations of the elements of the large planets of the solar system, are considerably in error at remote epochs on account of the neglect by these investigators of the terms arising from the squares and products of disturbing forces. Thus, Stockwell puts the length of the period of the principal inequalities of the eccentricities and perihelia of *Jupiter* and *Saturn* at 69140 years; but 55000 years is a much nearer approximation to it.

In ascertaining the modifications the perturbative function undergoes, by reason of terms of two dimensions with respect to disturbing forces, we are obliged to have recourse to the labors of LeVerrier, as no one else has derived them in the form which is necessary. I have given the results in this *Journal*, no. 204. From the values of the coefficients of R, the perturbative function, I deduce the following expression:

$$\begin{aligned} R = {} & 0''.002906504\,e^2 + 0''.002631048\,e'^2 + 0''.00859488\,e^4 + 0''.0926819\,e^2e'^2 \\ & + 0''.0591391\,e'^4 + 0''.28648\,e^6 + 7''.2004\,e^4e'^2 + 19''.8285\,e^2e'^4 + 5''.9589\,e'^6 \\ & - [0''.003565305 + 0''.0561361\,e^2 + 0''.145101\,e'^2 + 2''.87238\,e^4 + 23''.9129\,e^2e'^2 + 21''.7899\,e'^4]\,ee'\cos(\omega'-\omega) \\ & + [0''.0436099 + 4''.77063\,e^2 + 13''.1094\,e'^2]\,e^2e'^2\cos 2(\omega'-\omega) - 2''.61437\,e^3e'^3\cos 3(\omega'-\omega). \end{aligned}$$

The coefficients of this expression are generally the mean of the values deduced from LeVerrier's four equations; but, for the coefficient of $ee'\cos(\omega'-\omega)$, I have preferred the value which results from the equations for *Saturn*, as the motion of the eccentricities at the epoch 1850, thus obtained, more nearly agrees with that of my New Theory of *Jupiter* and *Saturn*: and, as the motion of the perihelion of *Saturn* at the same epoch, so far as it results from the inter-action of *Jupiter* and *Saturn*, from the same theory is 19″.95426, to bring about an agreement, I have supposed that LeVerrier's coefficient of the term $+18''.12312\,e'$ in the expression for $\dfrac{e'}{\cos\psi'}\dfrac{d\omega'}{dt}$ ought to be increased by 0″.3, and thus be read +18″.42312.

Desiring to pursue a similar course to that in a previous paper (*Annals of Mathematics*, Vol. V, p. 177), and get a form of the perturbative function in a measure independent of the values assumed for the masses of the planets and of the linear unit, I multiply the coefficients of the preceding expression by a factor whose logarithm is 1.9212280, and put $e^2 = 4\theta^2 - 4\theta^4$, $e'^2 = 4\theta'^2 - 4\theta'^4$, and express the development in powers of $\cos(\omega'-\omega)$ instead of in cosines of multiples of $\omega'-\omega$. Thus we have

$$\begin{aligned} \frac{a'}{mm'}\Omega = {} & 0.9697480\,\theta^2 + 0.8778427\,\theta'^2 + 10.5009\,\theta^4 + 65.4910\,\theta^2\theta'^2 + 78.0629\,\theta'^4 \\ & + 1506.4\,\theta^6 + 12905.5\,\theta^4\theta'^2 + 35803.5\,\theta^2\theta'^4 + 31652.9\,\theta'^6 \\ & - [1.1895555 + 58.9054\,\theta^2 + 193.0457\,\theta'^2 + 15244.4\,\theta^4 + 85660.1\,\theta^2\theta'^2 + 116032.8\,\theta'^4]\,\theta\theta'\cos(\omega'-\omega) \\ & + [116.4027 + 50818.3\,\theta^2 + 139849.0\,\theta'^2]\,\theta^2\theta'^2\cos^2(\omega'-\omega) - 55825.8\,\theta^3\theta'^3\cos^3(\omega'-\omega). \end{aligned}$$

If the coefficients of this expression are compared with those of the similar expression in the memoir quoted (p. 195) it will be seen how much the convergence of the series has been diminished by the inclusion of terms of two dimensions with respect to disturbing forces.

Denoting $m\sqrt{\mu a}$, $m'\sqrt{\mu' a'}$ severally by $\dfrac{1}{\lambda^2}$, $\dfrac{1}{\lambda'^2}$ we have the integral

$$\left(\frac{\theta}{\lambda}\right)^2 + \left(\frac{\theta'}{\lambda'}\right)^2 = K$$

K being an arbitrary constant whose value must be ascertained by substituting in the equation for θ and θ' the values they have at a determinate epoch, as 1850. The values we attribute to the masses of *Jupiter* and *Saturn* are severally $\frac{1}{1047.355}$ and $\frac{1}{3501.6}$, the first being Bessel's value augmented by a 2000th part. We take a' as the linear unit, and thence $\log a = 9.7367410$. Thus $\log \lambda = 1.5757581$, $\log \lambda' = 1.7721022$. We assume the following values of the eccentricities and longitudes of the perihelia for 1850:

$$e = 0.04825336, \qquad e' = 0.05605741,$$
$$\omega = 11^\circ\, 54'\, 26''.77. \qquad \omega' = 90^\circ\, 6'\, 38''.45.$$

But these values of course include the effect of the presence of *Uranus*, *Neptune*, etc., and, desiring to work as though *Jupiter* and *Saturn* were alone, we subtract from the values of $e \cos \omega$, $e \sin \omega$, etc., the terms due to the presence of the other planets. The values of the former, at the epoch 1850, are

$$e \cos \omega = +0.04721505, \qquad e \sin \omega = +0.00995615,$$
$$e' \cos \omega' = -0.00010829, \qquad e' \sin \omega' = +0.05605730$$

and the terms of these due to the other planets, derived from Stockwell's formulas, are

$$-0.00057480,\ +0.00194960,\ -0.00053070,\ +0.00180250.$$

By subtracting these we obtain

$$e \cos \omega = +0.04778985, \qquad e \sin \omega = +0.00800655,$$
$$e' \cos \omega' = +0.00042241, \qquad e' \sin \omega' = +0.05425481,$$

and thus result

$$e = 0.04845509, \qquad e' = 0.05125649,$$
$$\omega = 9^\circ\, 30'\, 38''.93, \qquad \omega' = 89^\circ\, 33'\, 14''.12.$$

The substitution of these values of e and e' in the integral equation gives $\log K = 93.7956760$. Then we can replace the variables θ and θ' by the expressions

$$\theta = [8.4735961] \sin \tfrac{1}{2} \nu \quad , \quad \theta' = [8.6699402] \cos \tfrac{1}{2} \nu .$$

The potential function Ω becomes then divisible by K, and we will put $\Omega = KR$, where this R must not be confounded with the R we used at the outset. Then, writing x for $\cos \nu$, we get

$$\begin{aligned} R = {} & 0.0006895184 + 0.0003724115\, x + 0.0000727015\, x^2 + 0.0000109446\, x^3 \\ & - [0.0004889780 + 0.0001386728\, x + 0.0000304563\, x^2] \sin \nu \cos \gamma \\ & + [0.0000616764 + 0.0000275660\, x] \sin^2 \nu \cos^2 \gamma \\ & - 0.0000082095 \sin^3 \nu \cos^3 \gamma , \end{aligned}$$

where, for brevity, γ is put for $\omega' - \omega$. The partial derivative of Ω with respect to K is needed in the discussion, and we have

$$\begin{aligned} \frac{\partial (KR)}{\partial K} = {} & 0.0008002223 + 0.0005743155\, x + 0.0001902984\, x^2 + 0.0000328338\, x^3 \\ & - [0.0006723170 + 0.0003598214\, x + 0.0000913689\, x^2] \sin \nu \cos \gamma \\ & + [0.0001604290 + 0.0000826980\, x] \sin^2 \nu \cos^2 \gamma \\ & - 0.0000246285 \sin^3 \nu \cos^3 \gamma . \end{aligned}$$

As the terms of these two equations, written above, are only the beginnings of infinite series we will add to them some additional terms obtained by induction, as thereby the results are probably rendered more exact. By substituting in the first the values of $x = \cos \nu$ and $\sin \nu \cos \gamma$ which hold at 1850, the value of the constant C, in the integral equation $R = C$, is ascertained. At that time we have $\nu = 109^\circ\, 3'\, 31''.62$, $\gamma = 80^\circ\, 2'\, 35''.19$. For convenience' sake we divide the equation $R = C$ by -0.000488978, the coefficient of $\sin \nu \cos \gamma$ in it. Thus, this coefficient is unity in the equation which follows. For brevity we write y for $\sin \nu . \cos \gamma$. Then

$$\begin{array}{rllll} 0.3800515 = & -[9.8817338]\, x & +[0.0000000]\, y & -[9.1008297]\, y^2 & +[8.225028]\, y^3 \\ & -[9.1722541]\, x^2 & +[9.4527020]\, xy & -[8.7510845]\, xy^2 & +[7.825028]\, xy^3 \\ & -[8.3508344]\, x^3 & +[8.7931640]\, x^2 y & -[8.2893993]\, x^2 y^2 & +[7.22503\ \ ]\, x^2 y^3 \\ & -[7.41747\ \ ]\, x^4 & +[8.0222860]\, x^3 y & -[7.71577\ \ ]\, x^3 y^2 & +[6.4250\ \ ]\, x^3 y^3 \\ & -[6.3722\ \ ]\, x^5 & +[7.13917\ \ ]\, x^4 y & -[7.03021\ \ ]\, x^4 y^2 & +[5.4250\ \ ]\, x^4 y^3 \\ & -[5.2149\ \ ]\, x^6 & +[6.1441\ \ ]\, x^5 y & -[6.2327\ \ ]\, x^5 y^2 & +[4.22\ \ ]\, x^5 y^3 \\ & -[3.95\ \ ]\, x^7 & +[5.0371\ \ ]\, x^6 y & -[5.3233\ \ ]\, x^6 y^2 & \\ & & +[3.82\ \ ]\, x^7 y & -[4.3019\ \ ]\, x^7 y^2 & \\ & & & -[3.17\ \ ]\, x^8 y^2 & \end{array}$$

$$\begin{array}{lllll} -[7.28163]\, y^4 & +[6.2828]\, y^5 & -[5.2210]\, y^6 & +[4.0961]\, y^7 & -[2.91]\, y^8 \\ -[6.6816\ \ ]\, xy^4 & +[5.4828]\, xy^5 & -[4.2210]\, xy^6 & +[3.10\ \ ]\, xy^7 & \\ -[5.8816\ \ ]\, x^2 y^4 & +[4.4828]\, x^2 y^5 & -[3.02\ \ ]\, x^2 y^6 & & \\ -[4.8816\ \ ]\, x^3 y^4 & +[3.28\ \ ]\, x^3 y^5 & & & \\ -[3.68\ \ ]\, x^4 y^4 & & & & \end{array}$$

The foregoing may be regarded as the equation in rectangular coordinates of a plane curve. It is obvious that we need consider only the portion between the limits ±1 of the abscissa. We therefore compute for every 0.1 of x

between these limits the corresponding value of y, and get the following table, where, in order to exhibit the quality of the function, the differences are also noted:

x	y	Δ	Δ^2	Δ^3	Δ^4	Δ^5
−1.0	−0.3471623	+707853				
−0.9	0.2463770	710183	+2330	−227		
−0.8	0.1753587	712286	2103	205	+22	+6
−0.7	0.1041301	714184	1898	177	28	12
−0.6	−0.0327117	715905	1721	137	40	8
−0.5	+0.0388788	717489	1584	89	48	10
−0.4	0.1106277	718984	1495	−31	58	13
−0.3	0.1825261	720448	1464	+40	71	10
−0.2	0.2545709	721952	1504	121	81	20
−0.1	0.3267661	723577	1625	222	104	21
0.0	0.3991238	725424	1847	344	122	23
0.1	0.4716662	727615	2191	489	145	22
0.2	0.5444277	730295	2680	656	167	37
0.3	0.6174572	733631	3336	860	204	42
0.4	0.6908203	737827	4196	1106	246	50
0.5	0.7646030	743129	5302	1402	296	80
0.6	0.8389159	749833	6704	1778	376	70
0.7	0.9138992	758315	8182	2224	446	+57
0.8	0.9897307	769021	10706	+2727	+503	
0.9	1.0666328	+782454	+13433			
1.0	+1.1448782					

The value of y expanded in powers of x, which might be derived from the foregoing table, forms a series too slowly convergent to be used, but the table will serve instead. The variables x and y do not move through the whole range of the table, but only between the two limits which satisfy the equation $x^2+y^2=1$. By trial from the data of the table we find for the first limit

$$x=\cos\nu=-0.9578284\ .\ y=\sin\nu\cos\gamma=-0.2873410,\quad \gamma=180°;$$

and, for the second limit

$$x=\cos\nu=+0.5735289\ ,\ y=\sin\nu\cos\gamma=+0.8191854,\quad \gamma=0°.$$

The angle ν then moves between the extreme values $\nu=55°\,0'\,11''.97$ and $\nu=163°\,18'\,4''.20$. These values correspond to the maximum and minimum values of the eccentricities, and we have

When $\gamma=0°$ $e=0.02747989$ $e'=0.08289313$
" $\gamma=180°$ $e=0.05885862$ $e'=0.01358174$

But these are the values which result when the interaction of *Jupiter* and *Saturn* is alone considered. To obtain the actual maximum and minimum, the sum of the coefficients of the terms arising from the presence of the other planets must be applied. According to STOCKWELL's investigation these are:

For *Jupiter* 0.0020673 ; *Saturn* 0.0019165.

Thence we have the maximum and minimum values as follows:

	Maximum Eccentricity	Minimum Eccentricity
Jupiter	0.06092592	0.02541259
Saturn	0.08480963	0.01166524

By putting

$$1-x^2-y^2=\sin^2\nu\sin^2\gamma=(0.5735289-x)(x+0.9578284)Q$$

Q is a factor whose variation is small relatively to its magnitude.

From the table giving the values of y corresponding to the set values of x may be obtained the values of Q corresponding to the same argument. Calling h the factor -0.000188978, by which we have divided the equation $R=C$, we get the values of $\dfrac{1}{h}\dfrac{\partial R}{\partial y}$ corresponding to the same argument, by differentiating the preceding equation connecting x and y, with respect to y, and substituting in the result the value of y from the preceding table. In this way are derived the following values of $\log Q$ and $\log\dfrac{1}{h}\dfrac{\partial R}{\partial y}$:

x	$\log Q$	$\log\left(\frac{1}{h}\frac{\partial R}{\partial y}\right)$
−1.0	0.1806684	9.9174264
−0.8	0.1815019	9.9249009
−0.6	0.1822846	9.9327715
−0.4	0.1830558	9.9409367
−0.2	0.1838695	9.9492582
0.0	0.1847981	9.9575473
0.2	0.1859370	9.9655508
0.4	0.1874115	9.9729259
0.6	0.1893944	9.9792066

As the variable ν does not move through the whole circumference, we substitute for it an auxiliary variable ψ possessing this property, such that

$$x=\cos\nu=-0.1921497\ -0.7656786\cos\psi.$$

Then for the elaboration of the equation

$$\frac{dt}{d\psi}=-\frac{\frac{dy}{dC}}{\sqrt{Q}}$$

we have the following table of values, given for intervals of 0.1 in x, in order to facilitate the following change to the variable ψ:

x	$-\dfrac{\frac{dy}{dC}}{\sqrt{Q}}$	Δ	Δ^2	Δ^3	Δ^4
−1.0	2008.862	−17.937			
−0.9	1990.925	18.235	−298	+47	
−0.8	1972.690	18.486	251	50	+3
−0.7	1954.204	18.687	201	59	9
−0.6	1935.517	18.829	142	63	1
−0.5	1916.688	18.908	79	71	8
−0.4	1897.780	18.916	−8	81	10
−0.3	1878.864	18.843	+73	84	3
−0.2	1860.021	18.686	157	101	17
−0.1	1841.335	18.428	258	108	7
0.0	1822.907	18.062	366	126	18
0.1	1804.845	17.570	492	143	17
0.2	1787.275	16.935	635	160	17
0.3	1770.340	16.140	795	184	24
0.4	1754.200	15.161	979	+214	+30
0.5	1739.039	−13.968	+1.193		
0.6	1725.071				

By interpolating in the preceding table we obtain the values of the function corresponding to equidistant values of the angle ψ, as follows:

ψ	x	$\dfrac{\frac{dy}{dC}}{\sqrt{Q}}$
0°	−0.9578284	2001.337
15	0.9317385	1996.652
30	0.8552468	1982.799
45	0.7335662	1960.435
60	0.5749890	1930.819
75	0.3903219	1895.948
90	−0.1921497	1858.547
105	+0.0060225	1821.808
120	0.1906896	1788.887
135	0.3492668	1762.278
150	0.4709174	1743.331
165	0.5174391	1732.249
180	+0.5735289	1728.638

By applying mechanical quadratures to the values in the last column we obtain for the periodic series representing the latter function,

$$\frac{dt}{d\psi} = 1861.5617 + 138.234\cos\psi + 3.217\cos 2\psi - 1.861\cos 3\psi$$
$$+ 0.205\cos 4\psi - 0.024\cos 5\psi + 0.003\cos 6\psi$$

Whence, by integration,

$$t + c = 1861.5617\,\psi + 138.234\sin\psi + 1.608\sin 2\psi$$
$$- 0.620\sin 3\psi + 0.051\sin 4\psi - 0.005\sin 5\psi.$$

Calling to mind that we have put $a' = 1$, it is obvious that the mean motion of *Saturn* is denoted by $\sqrt{\frac{3502.6}{3501.6}}$. But, when the Julian year is adopted as the unit of time, the mean motion of this planet is 43996″.08. The mean motion of the argument ψ in a year is then

$$\frac{43996''.08}{1861.5617}\sqrt{\frac{3501.6}{3502.6}} = 23''.63059\,;$$

and the period in which the principal inequalities of the eccentricities go through their round of values is 54844.16 years. Putting M for $23''.63059\,(t+c)$, we have

$$M = \psi + 15316''.6\sin\psi + 178''.2\sin 2\psi - 68''.7\sin 3\psi$$
$$+ 5''.7\sin 4\psi - 0''.5\sin 5\psi + 0''.1\sin 6\psi.$$

In order to have the proper value of M corresponding to a given date, from the value of c previously given for 1850.0, for the same epoch, we derive $\psi = 280°\ 6'\ 31''.13$; whence $M = 275°\ 53'\ 15''.3$. Thus the formula for M is

$$M = 275°\ 53'\ 15''.3 + 23''.63059\,(t - 1850).$$

It remains to devise some method of obtaining separately the quantities ω and ω'. For this purpose we employ the equation

$$\frac{d(\omega + \omega' - Ct)}{d\psi} = \frac{K\frac{dy}{dK} - x\frac{dy}{dx} - \frac{x^2 y}{1 - x^2}}{\sqrt{Q}}$$

Prolonging the series previously given for $\frac{d(KR)}{dK}$ by induction, we have

$$\begin{aligned}\frac{d(KR)}{dK} = {} & 0.0008002223 - [6.8275741]\,y + [6.2052829]\,y^2 - [5.3911379]\,y^3 \\ & + [6.7591505]\,x - [6.5560870]\,xy + [5.9174950]\,xy^2 - [5.0904079]\,xy^3 \\ & + [6.2794352]\,x^2 - [5.9607984]\,x^2y + [5.37190\ \ ]\,x^2y^2 - [4.52938\ \ ]\,x^2y^3 \\ & + [5.5163212]\,x^3 - [5.18949\ \ ]\,x^3y + [4.56630\ \ ]\,x^3y^2 - [3.70835\ \ ]\,x^3y^3 \\ & + [4.49829\ \ ]\,x^4 - [4.1581\ \ ]\,x^4y + [3.5007\ \ ]\,x^4y^2 - [2.6273\ \ ]\,x^4y^3 \\ & + [3.2683\ \ ]\,x^5 - [2.88\ \ ]\,x^5y + [2.1851\ \ ]\,x^5y^2 - [1.2963\ \ ]\,x^5y^3 \\ & + [4.39177]\,y^4 - [3.1733]\,y^5 + [1.8417]\,y^6 - [0.2102]\,y^7 \\ & + [4.04177]\,xy^4 - [2.7933]\,xy^5 + [1.4417]\,xy^6 \\ & + [3.43177]\,x^2y^4 - [2.1533]\,x^2y^5 + [0.7817]\,x^2y^6 \\ & + [2.5748\ \ ]\,x^3y^4 - [1.2533]\,x^3y^5 \\ & + [1.4748\ \ ]\,x^4y^4\end{aligned}$$

By attributing to x values evenly spaced from $x = -1.0$ to $x = 0.6$, and to y its corresponding values we get the following table of values for this function:

x	$1000\,\frac{d(KR)}{dK}$	Δ	Δ^2	Δ^3	Δ^4	Δ^5
−1.0	+0.5203093					
		+32024				
−0.9	0.5235117		+ 499			
		32523		+139		
−0.8	0.5267640		638		− 14	
		33161		125		+ 2
−0.7	0.5300801		763		12	
		33924		113		− 3
−0.6	0.5334725		876		15	
		34800		98		2
−0.5	0.5369525		974		17	
		35774		81		4
−0.4	0.5405299		1055		21	
		36829		60		13
−0.3	0.5442128		1115		34	
		37944		+ 26		10
−0.2	0.5480072		1111		41	
		39085		− 18		13
−0.1	0.5519157		1123		57	
		40208		75		16
0.0	0.5559365		1048		73	
		41256		118		19
0.1	0.5600621		900		92	
		42156		240		25
0.2	0.5642777		660		117	
		42816		357		29
0.3	0.5685593		+ 303		146	
		43119		503		−28
0.4	0.5728712		− 200		−174	
		42919		−677		
0.5	0.5771631		− 877			
		+42042				
0.6	+0.5813673					

We can write the differential equations determining ω and ω' thus:

$$\frac{d\omega}{d\psi} = -\tfrac{1}{2}\frac{d(KR)}{dK}\,\frac{\frac{dy}{dC}}{\sqrt{Q}} - \tfrac{1}{2}\,\frac{(1+x)\frac{dy}{dx} + \frac{xy}{1-x}}{\sqrt{Q}}$$

$$\frac{d\omega'}{d\psi} = -\tfrac{1}{2}\frac{d(KR)}{dK}\,\frac{\frac{dy}{dC}}{\sqrt{Q}} + \tfrac{1}{2}\,\frac{(1-x)\frac{dy}{dx} + \frac{xy}{1+x}}{\sqrt{Q}}$$

or

$$\frac{d\omega}{d\psi} = -\frac{[9.6598021]}{1-x} + F$$
$$\frac{d\omega'}{d\psi} = \frac{[9.1099174]}{1+x} + F'$$

where the values of F and F' corresponding to special values of x are contained in the following table:

x	F	Δ	Δ^2	F'	Δ	Δ^2
−1.0	+0.6866546			+0.6801311		
		−12070			−1122	
−0.9	0.6854476		−1818	0.6800189		−3268
		13888			1390	
−0.8	0.6840588		1379	0.6795799		2769
		15267			7159	
−0.7	0.6825321		961	0.6788640		2231
		16231			9393	
−0.6	0.6809090		588	0.6779247		1674
		16819			11067	
−0.5	0.6792271		270	0.6768180		1101
		17089			12168	
−0.4	0.6775182		− 13	0.6756012		− 537
		17102			12705	
−0.3	0.6758080		+ 159	0.6743307		0
		16943			12705	
−0.2	0.6741137		216	0.6730602		+ 506
		16727			12199	
−0.1	0.6724410		+ 145	0.6718403		966
		16582			11233	
0.0	0.6707828		− 128	0.6707170		1373
		16710			9860	
0.1	0.6691118		628	0.6697310		1689
		17338			8171	
0.2	0.6673780		1397	0.6689139		1876
		18735			6295	
0.3	0.6655045		2505	0.6682814		1891
		21240			4404	
0.4	0.6633805		1042	0.6678410		1713
		25282			2691	
0.5	0.6608523		−6058	0.6675719		+1290
		−31340			− 1401	
0.6	+0.6577183			+0.6674318		

It will be perceived that $\frac{d\omega}{d\psi}$ and $\frac{d\omega'}{d\psi}$ become infinite when in the first $x = 1$ and in the second $x = -1$. This is explained by the circumstance that, in this case, the one and the other of the eccentricities become zero, and, consequently, the positions of the perihelia indeterminate. Although, in the present application, x does not attain either of these values, yet it is necessary to separate, in the formulas, the portions which become infinite, viz.: the terms $\frac{f}{1-x}$ and $\frac{f'}{1+x}$ f and f' being constants. It thus becomes necessary to discover the values of f and f'. This we do by assimilating $\frac{1}{2}\frac{xy}{\sqrt{Q}}$, which is to be divided by $1-x$ or $1+x$, to a polynomial in x. The theory of algebraical equations shows that the remainders, left after the several divisions, are what the function divided becomes, when, in the first case, we make $x = 1$, and, in the second, $x = -1$. But we have

$$\frac{1}{2}\frac{xy}{\sqrt{Q}} = \frac{1}{2}xy\sqrt{\frac{(\mathrm{a}-x)(x-\mathrm{b})}{1-x^2-y^2}}$$

where a and b are respectively the superior and inferior limiting values of x. Thus the remainders are severally $\sqrt{(1-\mathrm{a})(1-\mathrm{b})}$ and $\sqrt{(1+\mathrm{a})(1+\mathrm{b})}$; and we have

$$f = -\sqrt{(1-\mathrm{a})(1-\mathrm{b})} \quad , \quad f' = +\sqrt{(1+\mathrm{a})(1+\mathrm{b})}.$$

Interpolating the values of F and F' to correspond to equal intervals of the auxiliary angle ψ, precisely as was done for the function $\frac{dt}{d\psi}$, we get

ψ	F	F'
0°	0.6861706	0.6801257
15	0.6858527	0.6800921
30	0.6848457	0.6798599
45	0.6830572	0.6791319
60	0.6804925	0.6776614
75	0.6773524	0.6754797
90	0.6739817	0.6729620
105	0.6706829	0.6706531
120	0.6675439	0.6689822
135	0.6644982	0.6680445
150	0.6616393	0.6676374
165	0.6594553	0.6674958
180	0.6586206	0.6674627

By the well known process we obtain for the periodic series represnting F and F':

$$\begin{aligned} F = {} & 0.6734830 + 0.0134490\cos\psi - 0.0007873\cos 2\psi + 0.0002755\cos 3\psi \\ & - 0.0002945\cos 4\psi + 0.0000505\cos 5\psi - 0.0000058\cos 6\psi, \\ F' = {} & 0.6734830 + 0.0070854\cos\psi + 0.0004198\cos 2\psi - 0.0007822\cos 3\psi \\ & - 0.0001050\cos 4\psi + 0.0000282\cos 5\psi - 0.0000036\cos 6\psi. \end{aligned}$$

The constant terms of the two functions have come out equal, as they should, and thus we have a check on the accuracy of the computation.

Integrating the expressions for $\frac{d\omega}{d\psi}$ and $\frac{d\omega'}{d\psi}$ we get

$$\begin{aligned} \omega = {} & c - \text{arc tan}\left[\,[9.6690575]\tan\tfrac{1}{2}\psi\right] + 0.6734830\,\psi + 2771''.1\sin\psi - 81''.2\sin 2\psi \\ & + 18''.9\sin 3\psi - 15''.2\sin 4\psi + 2''.1\sin 5\psi - 0''.2\sin 6\psi. \\ \omega' = {} & c' + \text{arc tan}\left[\,[0.7859273]\tan\tfrac{1}{2}\psi\right] + 0.6734830\,\psi + 1161''.5\sin\psi + 43''.3\sin 2\psi \\ & - 53''.8\sin 3\psi - 5''.4\sin 4\psi + 1''.2\sin 5\psi - 0''.1\sin 6\psi. \end{aligned}$$

It will be perceived from these formulas that, in the period of 54844.16 years, in which the eccentricities of the planets go through their round of values, the perihelion of *Saturn* advances through an arc 422° 27′ 13″.9, and that of *Jupiter* through an arc a circumference less, or 62° 27′ 13″.9.

Although we now have all the formulas necessary for ascertaining at any time the considered elements of the planets, in making further investigations on the perturbations of *Jupiter* and *Saturn* it is very convenient to have the four functions $e\cos\omega$, $e\sin\omega$, $e'\cos\omega'$ and $e'\sin\omega'$ expressed explicitly in terms of the time. For this purpose we derive the two expressions

$$\begin{aligned}\sqrt{1-x}\,{\textstyle\begin{smallmatrix}\cos\\ \sin\end{smallmatrix}}\,\omega &= +0.3730883\,{\textstyle\begin{smallmatrix}\cos\\ \sin\end{smallmatrix}}\,[1.1734830\,\psi+c+2774''.1\,\sin\psi-81''.2\,\sin 2\psi+\ldots.]\\ &\quad +1.0261360\,{\textstyle\begin{smallmatrix}\cos\\ \sin\end{smallmatrix}}\,[0.1734830\,\psi+c+2774''.1\,\sin\psi-81''.2\,\sin 2\psi+\ldots.]\\ \sqrt{1+x}\,{\textstyle\begin{smallmatrix}\cos\\ \sin\end{smallmatrix}}\,\omega' &= -0.7298805\,{\textstyle\begin{smallmatrix}\cos\\ \sin\end{smallmatrix}}\,[1.1734830\,\psi+c+1161''.5\,\sin\psi+43''.3\,\sin 2\psi-\ldots.]\\ &\quad +0.5245233\,{\textstyle\begin{smallmatrix}\cos\\ \sin\end{smallmatrix}}\,[0.1734830\,\psi+c+1161''.5\,\sin\psi+43''.3\,\sin 2\psi-\ldots.]\end{aligned}$$

We transform these expressions so that they stand thus:

$$\begin{aligned}e\ \cos\omega &= L\cos\chi-N\ \sin\chi+P\cos\chi'-S\sin\chi'\\ e\ \sin\omega &= L\ \sin\chi+N\cos\chi+P\sin\chi'+S\cos\chi'\\ e'\cos\omega' &= L'\cos\chi-N'\sin\chi+P'\cos\chi'-S'\sin\chi'\\ e'\ \sin\omega' &= L'\sin\chi+N'\cos\chi+P'\sin\chi'+S'\cos\chi'\end{aligned}$$

where χ denotes $1.1734830\,M+c$, and χ' $0.1734830\,M+c$, and compute the special values of L, N, etc., corresponding to equidistant values of M. The values of ψ, correspondent to the values of M are

M	ψ			M	ψ		
°	°	′	″	°	°	′	″
0	0	0	0.0	105	100	49	19.9
15	13	57	42.7	120	116	13	1.0
30	27	58	49.6	135	131	53	34.0
45	52	6	45.5	150	147	47	51.2
60	56	24	52.4	165	163	51	35.4
75	70	56	21.4	180	180	0	0.0
90	85	43	56.6				

The resulting values of L, N, etc., follow, they have been computed for every 15° of M, but it is thought sufficient here to give them for every 30°.

M	L	N	P	S
0	+0.01569403	0.00000000	+0.04316460	0.00000000
30	0.01568453	−0.00055468	0.04316546	−0.00000442
60	0.01566453	0.00098081	0.04316786	+0.00000199
90	0.01565339	0.00116239	0.04317138	0.00001605
120	0.01566451	0.00102276	0.04317516	0.00003573
150	0.01568794	−0.00058755	0.04317810	+0.00004339
180	+0.01569935	0.00000000	+0.04317924	0.00000000

M	L'	N'	P'	S'
0	−0.04827219	0.00000000	+0.03469046	0.00000000
30	0.04823472	+0.00184077	0.03468862	−0.00010047
60	0.04815368	0.00324916	0.03468358	0.00016630
90	0.04809893	0.00385871	0.03467646	0.00019278
120	0.04812057	0.00343532	0.03466902	0.00018175
150	0.04819279	+0.00201363	0.03466343	−0.00011503
180	−0.04823174	0.00000000	+0.03466139	0.00000000

The periodic developments of these quantities result as follow:

$$\begin{aligned}L &= +0.01567527-186\cos M+2167\cos 2M-90\cos 3M-23\cos 4M+10\cos 5M-2\cos 6M\\ N &= -0.00115622\sin M+2159\sin 2M+672\sin 3M-262\sin 4M+55\sin 5M-9\sin 6M\\ P &= +0.04317165-730\cos M+27\cos 2M-1\cos 3M\\ S &= +0.00002272\sin M-2351\sin 2M+765\sin 3M-112\sin 4M+97\sin 5M-11\sin 6M\\ L' &= -0.04817544-2436\cos M-7656\cos 2M+430\cos 3M-1\cos 4M-15\cos 5M+4\cos 6M\\ N' &= +0.00385831\sin M-10364\sin 2M-145\sin 3M+385\sin 4M-103\sin 5M+16\sin 6M\\ P' &= +0.03467617+1454\cos M-27\cos 2M-1\cos 3M+2\cos 4M\\ S' &= -0.00020065\sin M+866\sin 2M-759\sin 3M-25\sin 4M+29\sin 5M-7\sin 6M\end{aligned}$$

The coefficients of these expressions are given uniformly to 8 decimals. From these 8 equations we derive

$$\begin{aligned}e\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,\omega = &+0.01568298\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,\chi &&+0.01374883\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,\chi'\\ &-0.00059066\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(2\chi-\chi') &&+0.00001197\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(2\chi'-\chi)\\ &+0.00002545\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(3\chi-2\chi') &&+0.00000808\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(3\chi'-2\chi)\\ &+0.00000085\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(4\chi-3\chi') &&-0.00000263\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(4\chi'-3\chi)\\ &-0.00000094\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(5\chi-4\chi') &&+0.00000183\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(5\chi'-4\chi)\\ &+0.00000027\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(6\chi-5\chi') &&-0.00000045\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(6\chi'-5\chi)\\ &-0.00000001\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(7\chi-6\chi') &&+0.00000005\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(7\chi'-6\chi)\end{aligned}$$

$$\begin{aligned}e'\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,\omega' = &-0.04826849\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,\chi &&+0.03273483\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,\chi'\\ &+0.00192117\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(2\chi-\chi') &&+0.00012113\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(2\chi'-\chi)\\ &-0.00009390\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(3\chi-2\chi') &&-0.00000159\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(3\chi'-2\chi)\\ &+0.00000131\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(4\chi-3\chi') &&+0.00000186\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(4\chi'-3\chi)\\ &+0.00000206\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(5\chi-4\chi') &&+0.00000057\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(5\chi'-4\chi)\\ &-0.00000062\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(6\chi-5\chi') &&-0.00000020\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(6\chi'-5\chi)\\ &+0.00000010\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(7\chi-6\chi') &&+0.00000003\,{\textstyle\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}}\,(7\chi'-6\chi)\end{aligned}$$

By the substitution of the value of ψ which belongs to 1850 in the formulas for ω and ω', we ascertain that the arbitrary constants c and c' have the values

$$c = 340^\circ\ 15'\ 45''.2 \quad , \quad c' = 160^\circ\ 15'\ 46''.2.$$

These values should differ by exactly 180°; the small deviation is attributable to accumulated errors of calculation; we adopt $c = 340^\circ\ 15'\ 45''.7$. The expressions for the two arguments χ and χ' are then

$$\begin{aligned} \chi &= 301^\circ\ 0'\ 13''.5\ + 27''.73010\ (t - 1850), \\ \chi' &= \ \ 28^\circ\ 7'\ 28''.2\ +\ 4''.09951\ (t - 1850). \end{aligned}$$

We see that, in spite of the extreme slowness of convergence exhibited by the coefficients of the original form of R, the final expressions we have arrived at for determining the elements appear tolerably convergent.

In his recent prize memoir (*Die Säcularen Veränderungen der Bahnen der Grossen Planeten*, p. 256), Mr. PAUL HARZER has, instead of our annual motions of the arguments χ and χ', the values 31″.156517 and 3″.918590. The somewhat large difference between the values of the motion of χ is due, I think, to a cause which Mr. HARZER has noted in the *Nachtrag* to his memoir, as well as to his neglect of second order terms which arise from the argument twice the movement of *Saturn* minus that of *Jupiter*.*

The expressions we have obtained need to be completed by the addition of the terms arising from the presence of the six planets not considered in this investigation. Adapted from the formulas of STOCKWELL, they are

$$\begin{aligned} e \substack{\sin \\ \cos}\, \omega = &-0.0000061 \substack{\sin \\ \cos} (\ 87^\circ\ 18' + \ 5''.50543t) + 0.0000104 \substack{\sin \\ \cos} (\ 15^\circ\ 38' + \ 7''.32997t) \\ &-0.0000012 \substack{\sin \\ \cos} (331^\circ\ 16' + 17''.37128t) + 0.0000006 \substack{\sin \\ \cos} (136^\circ\ \ 5' + 18''.03675t) \\ &+0.0000645 \substack{\sin \\ \cos} (\ 71^\circ\ 51' + \ 0''.63867t) + 0.0019845 \substack{\sin \\ \cos} (107^\circ\ 41'\ 40'' + 2''.70598t)\ , \\ e' \substack{\sin \\ \cos}\, \omega' = &-0.0000053 \substack{\sin \\ \cos} (\ 87^\circ\ 18' + \ 5''.50543t) + 0.0000107 \substack{\sin \\ \cos} (\ 15^\circ\ 38' + 7''.32997t) \\ &-0.0000077 \substack{\sin \\ \cos} (331^\circ\ 16' + 17''.37128t) + 0.0000076 \substack{\sin \\ \cos} (136^\circ\ \ 5' + 18''.03675t) \\ &+0.0000725 \substack{\sin \\ \cos} (\ 71^\circ\ 51' + \ 0''.63867t) + 0.0018127 \substack{\sin \\ \cos} (107^\circ\ 41'\ 40'' + 2''.70598t). \end{aligned}$$

It should be mentioned that, in the preceding investigation, the effect of the terms of two dimensions as to planetary masses in the inter-action of *Jupiter* and *Saturn* on the expressions just written has been neglected. Also the influence of the terms of the third order with respect to eccentricities and inclinations has been neglected, except when they involved solely the eccentricities of *Jupiter* and *Saturn*. These effects are, however, probably small in comparison with those which are considered.

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* On the latter point consult *Astron. Papers of the American Ephemeris*, Vol. IV, p. 251.

EPHEMERIS OF (16) *PSYCHE*,

BY SIDNEY D. TOWNLEY.

For some time past I have been working on a redetermination of the orbit of *Psyche*, preparatory to the computation of the perturbations from 1900 on. It is desirable to have observations of the planet at each of the remaining oppositions of the century. The next opposition will be 1897 Feb. 22.

I have computed the following finding ephemeris from SCHUBERT's elements and perturbations given in *A.N.* 1790.

Ann Arbor, 1897 *Feb.* 4.

Berlin M.T.	α	δ	log Δ
	h m s	° ′	
1897 Feb. 18.5	10 27 47	+ 9 54.3	0.3432
22.5	24 38	10 15.9	.3434
26.5	21 28	37.3	.3445
Mar. 2.5	18 21	10 58.2	.3465
6.5	15 21	11 18.2	.3495
10.5	12 30	37.1	.3533
14.5	9 52	11 54.6	.3579
18.5	10 7 28	+12 10.6	0.3633

OBSERVATIONS OF RECENTLY DISCOVERED VARIABLES,

BY J. A. PARKHURST.

7792. *SS Cygni*.*

I have followed this new short-period variable through one of its 40-day periods, with these results:

	M		M
1896 Dec. 20	11.0	1897 Jan. 19	8.5
23	11.0	21	8.6
1897 Jan. 1	10.7	22	8.7
6	11.0	26	9.1
8	11.1	28	9.4
9	10.9	29	9.9

The 10 cloudy days between Jan. 9 and 19 rendered the time of the sudden rise uncertain. The comparisons were all made between 12^h and 14^h Greenwich mean time.

ANDERSON'S NEW VARIABLE IN *Andromeda*.†

Since the note in *A.J.* 394 I have obtained additional observations. The results so far are as follows:

	M		M
1897 Jan. 19	11.6	1897 Jan. 22	11.9
21	<11.3	23	12.2

The three nearest comparison-stars, with their approximate magnitudes, are: $12^M.2$ prec. 2^s, 3′ south; $12^M.4$ prec. 5^s, 1′ south; $12^M.5$ foll. $15^s.4$, 1′.4 north.

Marengo, Ill., 1897 *Jan.* 30.

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* See *A.J.* 392, p. 64.

† The above observations, in connection with those of ANDERSON, seem to establish the variability of this star, whose definitive notation will therefore be, 267 *V Andromedae* (1900) $0^h\ 44^m\ 39^s$, +35° 6′.5; (1855) $0^h\ 42^m\ 13^s$, +34 51′.8. ED.

CONFIRMATIONS OF VARIABILITY,

BY ROBERT H. WEST.

(268). = *Sculptoris.*[*]

Sufficient observations have been made this year to fully confirm the variability of this star, announced by me in *A.J.* 371. They are as follows:

	M		M
1896 Aug. 2	9.95	1896 Nov. 7	10.9
Sept. 15	9.4	25	11.7
Oct. 7	9.8	Dec. 8	12.5
28	10.4		

Comparing these observations with the light-curve of last year, we find a maximum indicated for 1896 August 24. While this determination is only approximate, it enables us to assign a provisional period of 250 days, a maximum having been observed on 1895 December 17. This period is consistent with the absence of the star from the Cordoba *Durchmusterung*. The neighboring star, C.DM. −35°272, was observed 89 days after, 55 and 51 days before, and 55 days after the maximum of the variable, according to this period, at all of which times the star would be below the limit included in the *Durchmusterung*.

C.DM. −27°15202.[†]

The variability of this star, suspected at Cordoba, has lately been confirmed by the Harvard College Observatory (*A.N.* 3379); the number, however, is erroneously given as 15203. My observations give independent confirmation: eight observations from 1896 September 7 to November 20 indicate a maximum of $8^M.0$ on September 17, the brightness being $9^M.8$ when last observed. On 1895 August 22, it was $11^M.5$.

C.DM. −37°12782.[§]

Four observations of this star confirm the variability, announced by H.C.O. (*A.N.* 3362). Its brightness was $9^M.6$ on 1896 August 1 and September 7, $9^M.4$ on 1896 September 15, and $8^M.5$ on 1896 October 7.

C.DM. −30°19418.[‖]

I am able to confirm the variability of this star, announced by H.C.O. (*A.N.* 3362). My observations are as follows:

	M		M
1896 Sept. 7	8.4	1896 Nov. 20	7.9
15	8.4	Dec. 15	8.0
Oct. 28	7.8	1897 Jan. 13	7.65
Nov. 13	7.8		

Syrian Protestant College, Beirut, Syria, 1897 *Jan.* 14.

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[*] 268 *X Sculptoris:* (1900) $0^h\,44^m\,42^s$, −35 27′.8.
8302 *Y Sculptoris:* (1900) $23^h\,3^m\,40^s$, −30 40.5.

[†] 7538 *RR Capricorni:* See *A.J.* 392, p. 64.

[§] 6686 *U Coronae Austr.:* " " " p. 64.

ED.

NEW ASTRONOMICAL WORK.

Publications of the Washburn Observatory of the University of Wisconsin, 1896.

Vol. IX, Part I, contains the details of a discussion of a determination of the constant of aberration, made by the Director, GEO. C. COMSTOCK, from his own and Mr. FLINT's observations in 1890–92, by LOEWY's method, but with a modification of the apparatus which consists in the introduction before the object-glass of three reflecting surfaces instead of two. This modification appears to possess some advantages. A provisional discussion of a part of the observations, published in *A.J.*, 261, gave for the aberration constant 20″.494. An analogous solution for the whole, in the present volume, gives 20″.499. A peculiar and obscure form of systematic error, however, appeared, as between the two observers, dependent apparently on the distance apart of the two images in the field of the telescope. For reasons which are given by the author the assumptions are made that this error affects the observations of only one of the observers, and that those of the other are subject, on the contrary, to peculiarly large accidental errors. Reducing the results to the latter, as a zero, but rejecting a part of his observations, and assigning the remainder of them one-half weight, the aberration becomes 20″.443.

Subsidiary investigations on the coefficient of atmospheric expansion, and on the effect upon the refraction of aqueous vapor, and of atmospheric dispersion due to the color of the stars, are included in the volume.

Vol. IX, Part II, by A. S. FLINT, gives the determinations made in 1892–93, with the Repsold Meridian-Circle, of the right-ascensions of the stars employed in the foregoing investigation with the prism-apparatus.

Vol. X, Part I, contains the micrometrical measurements, 1892–96, made by the Director, of double stars, principally well known binaries of rapid motion.

C.

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ON THE DETERMINATIONS OF THE CONSTANT OF ABERRATION MADE AT PULKOWA,

By M. NYRÉN.

In the interesting remarks of Mr. Gill, upon certain astronomical constants, reproduced in the *Bulletin Astronomique* for September, some doubts are expressed on the certainty of the results obtained at Poulkova by observations in the prime-vertical. In part these same doubts may be read in Mr. Newcomb's *Astronomical Constants*, and more explicitly still in an article by the same author in the *Astronomical Journal*, no. 369. It was in reply to that article that I wrote for the *Journal*, more than six months ago, the remarks that I take the liberty of producing here with some slight changes. To prevent all misunderstanding I should say that my reply was not sent directly* to the eminent Editor of the *Astronomical Journal*.

The doubts raised by Mr. Newcomb, and supported by Mr. Gill, with regard to the results of my prime-vertical observations, rest on the supposition that the small modifications, dependent on brightness, noticed by some astronomers in the personal equation for meridian-transits, will affect also prime-vertical transits of zenithal stars: they suppose that certain traces of such differences that have been noted depend on a general law; they suppose further that the images of such stars, seen in the fully illuminated field of the telescope, are sensibly larger than those seen in twilight without illumination. If these three hypotheses are well based we must, without doubt, regard the results of my observations as subject to the error mentioned.

The determination of W. Struve, obtained by the same instrument in the same way, is in all probability below rather than above the true value. Hence it follows that this method of observation, in an authenticated case, does not influence the result in the manner indicated by Mr. Newcomb. Neverthelesss, this proof is not decisive for my observations. On the one hand, the equation for brightness might have been insensible in Struve's case without being so in mine; on the other hand, the mean brightness of Struve's stars is considerably greater than for those in my series, a fact which permitted his making a large part of the observations during daylight in both branches of the prime-vertical, while for fainter stars observation is necessarily limited to night and twilight. In my series we find, among stars much fainter, also those of Struve, observed now nearly in the same conditions as they were by him. Now, if the error in question is a function of brightness, it should, for this reason, appear in the differences of the corrections for stars of different brilliancy. Let us divide, then, the 24 stars in my series into three groups, according to magnitude, and take the means of the corrections given in my *Aberration des Étoiles Fixes*, p. 35–36, with the corresponding weights. We thus have

	Corrections	Stars	Weight
Stars brighter than $4^{M}.0$,	+0″.163	5	554
" between $4^{M}.0$ and $5^{M}.0$,	+0.030	6	289
" fainter than $5^{M}.0$,	+0.080	13	516

These results are incompatible with such an error as has been supposed; the brightest stars, which were all observed also by Struve, give the largest correction for the aberration employed.

In reflecting on the method of observing prime-vertical transits of zenithal stars, it also appears to me improbable that an error of this sort can affect them. The personal error, aside from some exceptional cases, ought not to be interpreted as produced by defective estimation of the geometrical bisection of the observed image; the error is committed in the expression, by one manner or another, of the phenomenon in a function of the time. It follows that, if the apparent velocity of the object bisected has diminished to a certain limit, the personal error will be imperceptible, or, at least, will not change with any small modification in brilliancy of the image. This limit is doubtless attained as well in prime-vertical transits of zenithal stars as in meridian-transits of polar stars.

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* From what the author here says, taken in connection with a letter, dated 1896 May 7, received from him by the Editor, it appears that this article was sent by him indirectly, but that by some mischance it has never been received. Thus, Dr. Nyrén's letter communicated the fact that he had prepared such an article for this *Journal*, and would shortly forward it for printing, but that he desired preliminarily to submit it to Prof. Newcomb for perusal. From further expressions of his letter it would appear that he intended that the manuscript should subsequently be forwarded to the *Journal*. If so, by some misunderstanding or miscarriage, it has never been received. Under these circumstances it seems eminently proper that the article should be here reproduced, by translation from the *Bulletin Astronomique*. — Ed.

The truth of this proposition may be demonstrated also in another way. Although the velocity of the motion at right angles to the vertical threads is very slow for all stars observed in the prime-vertical, there is a very considerable difference in velocity between the stars passing the meridian a few minutes from the zenith, and those most distant from it, comprised in my series. From this point of view we can also divide them into three groups, thus:

Zenith-distance		Corrections	Stars	Wt.
Greater than 50′,	mean 64	+0.″117	7	545
Between 50′ and 25′,	" 40	+0.031	9	357
Less than 25′,	" 15	+0.123	8	157

The mean velocity in the given direction, for the first group, is twice as great as for the last; nevertheless, the corrections are nearly identical. From this agreement of the corrections found from stars of such different velocity, it appears to me proved that the bisection of the images, expressed in time, was sensibly the same for all. Besides, considering that the stars of the first group undergo many more variations of illumination, as between the two branches of the prime-vertical, than do those of the last — the interval between east and west being for the first 133^m, and for the last 65^m — we see in this agreement of the corrections a further proof that the observations of my series are free from this supposed error.

The objection made to the determination of the aberration by the transits of polar stars by Wagner does not appear to me to be better founded. It must not be here forgotten that the transits are observed as often below as above the pole. Consequently the conditions of observation, so far as the difference between night and day only is concerned, are the same for the maxima as for the minima of the aberration. As to the faint polar stars, we observe in our transit-instrument either amplitude of the aberration only near midnight. So long as we do not consider an origin of personal error other than the one above assumed, it appears to me beyond debate that the transits of polar stars observed by my late colleague provide very precious materials for the determination of the aberration.

The other objection, raised by Mr. Gill, to my series of observations, relating to the influence of variation of latitude, has certainly a better foundation, at least so far as isolated observations are concerned. The considerable difference of the corrections found from stars in different right-ascensions is the proof of this; and unfortunately the elements of this variation are yet too little known to permit its elimination by subsequent corrections. But it should here be remarked that the certainty of the mean result is much greater than the separate corrections would imply. By the method — later developed more in detail by Mr. Küstner, but the advantages of which, in case of a variable latitude, I had already indicated in my memoir, p. 39 — of observing, evening and morning at the same time of the year, stars about 12^h apart in right-ascension, we may reduce nearly to nothing the influence of variation of latitude on the mean correction of the whole series, separated into groups according to right-ascension.

For a future determination of the constant of aberration it appears to me beyond doubt that we should choose, either Struve's method of observing in the prime-vertical, or that of Horrebow. The latter has the advantage that more stars can be found suitable for observation, while in the prime-vertical the individual observations are more exact. Before making use of other proposed methods, we should examine whether the risk is not incurred of introducing systematic errors graver than those which it is sought to avoid. And the occasions of obtaining series of observations of polar stars so homogeneous as those of Wagner are too rare for them to be included in the program.

NOTE ON THE FOREGOING ARTICLE.

By SIMON NEWCOMB.

The preceding paper reached me in May last while I was travelling abroad. I greatly regret that, owing to the circumstance of my being away from home, I overlooked or forgot Dr. Nyrén's intimation that he would like to have it published in the *Astronomical Journal*. Only now am I reminded of this wish. It may be remarked that the comparison of results obtained from stars of different magnitudes does not disprove the existence of the source of systematic error which I pointed out. This source is to be found in the systematic difference between the apparent brilliancy of a star during its transit over the east and west verticals in the morning or evening twilight, owing to the increasing brightness of the sky in the one case and the diminishing brightness in the other. This cause would affect stars of all magnitudes in the same direction. Yet I quite agree with Dr. Nyrén that there is no certainty that this equation exists in the case of his prime vertical observations. It was suggested by me simply as a more or less probable conclusion, not as an established one.

OBSERVATIONS OF COMETS,

MADE AT THE LICK OBSERVATORY,

BY C. D. PERRINE.

1896 Mt. Hamilton M.T.		∗	No. Comp.	☄ − ∗		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
Comet *d* 1896 (Giacobini).									
	h m s			m s	′ ″	h m s	° ′ ″		
Nov. 28	6 14 50	1	*d*10 . 8	+0 12.49	−1 30.1	21 16 32.62	−12 17 50.8	9.274	0.583
Comet *f* 1896 (Perrine).									
Nov. 28	7 28 22	3	*d*10 , 10	−0 38.99	+7 26.0	19 54 27.88	+ 7 36 10.2	9.621	0.687
29	7 14 56	4	10 , 7	−1 11.52	+4 52.9	19 53 59.85	+ 7 5 15.7	9.612	0.684
Dec. 1	7 38 36	5	*d* 7 , 3	−0 12.46	−0 19.3	19 53 8.69	+ 6 4 4.8	9.641	0.702
1	8 33 16	6	*d*10 , 8	−0 5.10	+6 27.8	19 53 7.79	+ 6 3 1.9	9.669	0.716
2	7 17 44	8	*d*10 , 8	−0 17.24	+3 55.9	19 52 45.76	+ 5 35 1.3	9.626	0.700
4	7 17 48	9	14 , 8	−0 51.34	−1 54.4	19 52 4.18	+ 4 37 35.3	9.633	0.707
9	6 47 40	10	4	. . .	−3 25.8	. . .	+ 2 23 14.0	. .	0.716
9	6 54 4	10	*d* 7	−0 14.62	. . .	19 50 42.11	. . .	9.630	. .
Comet *g* 1896 (Perrine).									
Dec. 15	8 57 10	11	*d*10 . 8	+0 4.08	−0 10.7	1 40 40.97	+ 3 40 7.8	9.064	0.689
17	9 53 5	12	*d*10 , 8	+0 21.06	+7 10.3	1 54 25.92	+ 2 57 19.4	9.328	0.700
20	7 13 25	13	*d*10 . 9	−0 15.13	−5 6.2	2 13 15.23	+ 2 3 3.5	*n*9.079	0.707
1897									
Jan. 4	8 49 7	15	14 , 8	−0 57.85	−2 29.6	3 35 13.39	− 0 35 29.8	8.462	0.732
5	7 19 19	16	*d*10 , 8	−0 15.08	−1 51.0	3 39 26.98	− 0 39 0.0	*n*9.185	0.734
11	9 50 39	17	*d*10 , 8	+0 5.33	−3 54.0	4 4 49.34	− 0 48 53.2	9.173	0.736
20	6 44 28	19	*d*10 , 8	+0 5.31	+4 17.8	4 36 12.36	− 0 31 16.2	*n*9.332	0.732
21	7 12 48	20	*d*10 . 8	+0 18.11	−6 27.4	4 39 27.60	− 0 27 32.9	*n*9.201	0.732
22	7 51 34	22	*d*10 , 8	+0 14.68	−7 3.7	4 42 41.68	− 0 23 20.2	*n*8.914	0.732

Mean Places for 1896.0 and 1897.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	21 16 16.89	+3.24	−12 16 32.3	+11.6	Micrometer comparison with ∗2
2	21 14 21.84	+3.23	−12 15 25.6	+11.4	½ (Santini 2391 + Munich 28009)
3	19 55 4.52	+2.35	+ 7 28 34.2	+10.0	⅓ (Munich (2) 9591 + Munich (1) 22563)
4	19 55 9.02	+2.35	+ 7 0 13.0	+ 9.8	⅓ (Mu. (1) 22566 + Bonn VI, 6°4395 + Sant. 1384)
5	19 53 18.80	+2.35	+ 6 4 14.9	+ 9.2	Schjellerup 7715, 7716
6	19 53 10.54	+2.35	+ 5 56 25.0	+ 9.1	Micrometer comparison with ∗7
7	19 53 2.81	+2.35	+ 5 47 15.7	+ 9.1	Schjellerup 7714
8	19 53 0.64	+2.36	+ 5 30 56.4	+ 9.0	⅓ (2 Schj. 7712 + Munich (4) 22437)
9	19 52 53.14	+2.38	+ 4 39 21.1	+ 8.6	Boss, Albany A.G. 6924
10	19 50 54.30	+2.43	+ 2 26 32.5	+ 7.3	" " " 6911
11	1 40 32.58	+4.31	+ 3 39 52.6	+25.9	" " " 502
12	1 54 0.49	+4.37	+ 2 49 44.0	+25.1	" " " 556
13	2 13 25.90	+4.46	+ 2 7 45.6	+24.1	Micrometer comparison with ∗14
14	2 13 56.43	+4.46	+ 2 11 12.1	+24.1	Boss, Albany A.G. 653
15	3 36 9.56	+1.68	− 0 33 6.0	+ 5.8	⅓ (Göttingen 949, 50 + Schj. 1112 + Mu. (2) 715)
16	3 39 40.37	+1.69	− 0 37 14.8	+ 5.8	½ (Göttingen 961 + Rad. (3) 878)
17	4 4 42.28	+1.73	− 0 45 4.1	+ 4.9	Micrometer comparison with ∗18
18	4 6 16.34	+1.74	− 0 41 23.4	+ 4.9	½ (Paris 4858 + Göttingen 1089)
19	4 36 5.23	+1.82	− 0 35 37.9	+ 3.9	Göttingen 1282
20	4 39 7.66	+1.83	− 0 21 9.3	+ 3.8	Micrometer comparison with ∗21
21	4 39 5.00	+1.83	− 0 13 51.0	+ 3.8	Göttingen 1308
22	4 42 25.17	+1.83	− 0 16 20.2	+ 3.7	½ (Göttingen 1314 + Paris 5490)

Dec. 1. First observation made through haze and clouds.
" 4. Telescope swayed by the wind.
" 9. Haze prevents completion of measures.
" 17. Windy. Comet faint in the moonlight.
" 20. Comet faint in the moonlight.
Jan. 20. Comet much fainter. Seeing poor.
" 22. Hazy. South wind sways telescope.

Comet Giacobini observed with 36-inch telescope.
Comets *f* and *g* observed with 12-inch telescope.

Lick Observatory, University of California, 1897 *Jan.* 23.

OBSERVATIONS OF COMET *g* 1896,

MADE AT THE VASSAR COLLEGE OBSERVATORY,

BY MARY W. WHITNEY.

1897 Greenwich M.T.	✱	No. Comp.	☄ – ✱ Δα	☄ – ✱ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
			m s	′ ″	h m s	° ′ ″		
Jan. 7 16 14 43	1	9	+0 19.66	+2 19.2	3 18 23.13	−0 44 48.8	9.525	0.772
25 14 38 27	2	6	−1 41.11	−8 17.7	4 51 37.30	−0 10 19.8	9.145	0.769
26 13 7 21	2	11	+1 1.12	−1 22.8	4 51 22.83	−0 5 55.0	*n*8.496	0.768

Mean Places for 1897.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 18 1.76	+1.71	−0 47 13.5	+5.5	Micr. comp. with ½(Glas.(1) 906 + Rad.(90) 902)
2	4 53 19.87	+1.84	−0 1 35.3	+3.2	Copeland and Börgen 1101, 2

On Jan. 25 and 26, comet very faint and difficult.

ELEMENTS AND EPHEMERIS OF COMET *g* 1896.

BY F. RISTENPART.

The following elements are based on three normal places, 1896 Dec. 10.5 (7 obs.), 1896 Dec. 28.5 (6 obs.), 1897 Jan. 5.5 (14 obs.). They also represent an observation of Jan. 12 (Nice) within $+0^s.18$ in α, and $-0''.3$ in δ, and two further observations, of Jan. 26 and 27, agree exactly with an ephemeris computed with five-place logarithms. The elements are

$$T = 1896 \text{ November } 24.65674 \text{ Mean Berlin Time}$$

$$\left.\begin{aligned}\omega &= 163^\circ\ 53'\ 30''.0\\ \Omega &= 246\ \ 34\ \ 35\ .9\\ i &= \ \ 13\ \ 40\ \ 25\ .9\end{aligned}\right\}1897.0$$

$$\begin{aligned}\log q &= 0.045405\\ \log e &= 9.832054 \qquad \varphi = 42^\circ\ 47'\ 17''.0\\ a &= 3.4617 \qquad\quad \mu = 550''.901\\ U &= 2352.5 \text{ days} = 6.441 \text{ years}\end{aligned}$$

The comet, which can approach to *Jupiter's* orbit within 0.053 in longitude 247°, thus almost exactly in his ascending node, was in the neighborhood of that planet in the year 1888. But, while the comet was passing through this point on April 27, the heliocentric longitude of *Jupiter* was only 239°; therefore the perturbations of the comet were great, but not enough to change the orbit entirely. It will be necessary to compute these perturbations and then carry the comet's path backward, in order to judge whether the comet is identical with BIELA's, or is only a body which formerly moved in BIELA's orbit. The two orbits, whose major axes now include an angle of 60°, intersect one another 161° from the common ascending node, at $v = 297°$ for BIELA, and $v = 357°$ for PERRINE. Only refined elements of PERRINE's comet, based on a sufficient heliocentric arc in the present apparition, and the retrospective computation of the perturbations, can enable us to settle the question whether at any previous time the two comets have simultaneously occupied this point of intersection. Since I wish to undertake the definite determination of the comet's orbit and its relations to BIELA's, I hope that observers with the great American telescopes will follow it as long as possible. The following ephemeris will represent the comet's path satisfactorily. It will be continued, if necessary.

Heidelberg, 1897 *Jan.* 27.

EPHEMERIS OF COMET *g* 1896 FOR BERLIN MIDNIGHT.

Date	App. α	App. δ	log Δ	Br.
	h m s	° ′		
1897 Feb. 22.5	6 1 18	+2 35.2		
24.5	5 39	47.1	9.97214	0.05
26.5	9 56	2 58.6		
28.5	14 11	3 9.8	9.99787	
Mar. 2.5	18 23	20.6		
4.5	22 33	31.0	0.02293	0.04
6.5	26 41	41.0		
8.5	30 46	50.6	0.04723	
10.5	34 49	3 59.8		
12.5	38 50	4 8.6	0.07082	0.03
14.5	42 49	16.9		
16.5	46 47	24.8	0.09374	
18.5	50 43	32.1		
20.5	54 38	39.0	0.11599	0.02
22.5	6 58 31	45.4		
24.5	7 2 23	51.3	0.13760	
26.5	6 13	4 56.8		
28.5	7 10 1	+5 1.9	0.15857	0.01

Brightness on Dec. 10 taken as unity.

ELLIPTIC ELEMENTS AND EPHEMERIS OF COMET *g* 1896,

By C. D. PERRINE and R. G. AITKEN.

The following system of elements is based upon normal places from observations on December 8, 9, 10 (Mt. Hamilton), Dec. 10 (Munich, Bamberg, Strassburg, Nice), Dec. 11 (Vassar, Edinburgh), Jan. 2 (Bamberg, Strassburg), Jan. 4, 5, 6, 8 (Mt. Hamilton), Jan. 20, 21, 22, 23, 24, 25 (Mt. Hamilton).

Epoch 1896 Dec. 10.0 Greenw. M.T.

$$M = 2^\circ\ 22'\ 49''.6$$

$$\left.\begin{array}{rcl}\omega & = & 163\ \ 52\ \ \ 8\ .7\\ \Omega & = & 246\ \ 36\ \ \ 4\ .4\\ i & = & 13\ \ 39\ \ 24\ .5\end{array}\right\}1897.0$$

$$\log a = 0.536366$$
$$\log e = 9.830734$$
$$\log \mu = 2.745458$$
$$\varphi = 21^\circ\ 18'\ 49''.0$$

Period $6^y.376$

Constants for the Equator and Mean Equinox of 1897.0.

$$x = r[9.989557]\ \sin(139^\circ\ 51'\ 56''.0 + v)$$
$$y = r[9.979418]\ \sin(\ 45\ \ 51\ \ \ 7\ .9 + v)$$
$$z = r[9.568973]\ \sin(\ 83\ \ 39\ \ 27\ .5 + v)$$

Lick Observatory, University of California, 1897 *Feb.* 7.

Ephemeris for Greenwich Mean Midnight.

1897	α	δ	log Δ	Br.
	h m s	° ′ ″		
Feb. 20.5	5 56 59.0	+2 23 55	9.9151	0.016
22.5	6 1 23.8	2 35 51		
24.5	6 5 15.0	2 47 31	9.9716	0.039
26.5	6 10 3.0	2 59 0		
28.5	6 14 18.0	3 10 8	9.9973	0.033
Mar. 2.5	6 18 30.4	3 20 56		
1.5	6 22 10.3	3 31 21	0.0221	0.028
6.5	6 26 47.9	3 41 23		
8.5	6 30 53.4	3 51 0	0.0167	0.024
10.5	6 34 57.0	4 0 11		
12.5	6 38 58.6	4 8 56	0.0703	0.021
14.5	6 12 58.2	4 17 11		
16.5	6 16 56.0	4 25 4	0.0932	0.018
18.5	6 50 52.2	4 32 26		
20.5	6 54 46.7	4 39 20	0.1151	0.016
22.5	6 58 39.7	4 45 46		
24.5	7 2 31.2	4 51 44	0.1370	0.014
26.5	7 6 21.3	4 57 12		
28.5	7 10 10.1	5 2 11	0.1580	0.012
30.5	7 13 57.6	5 6 42		
Apr. 1.5	7 17 44.0	5 10 41	0.1781	0.011
3.5	7 21 29.2	5 14 16		
5.5	7 25 13.3	5 17 19	0.1981	0.009
7.5	7 28 56.2	5 19 53		
9.5	7 32 38.1	+5 21 57	0.2173	0.008

Brightness on December 8 unity.

DISCOVERY OF THREE BRILLIANT STELLAR SYSTEMS IN THE SOUTHERN HEMISPHERE,

MADE WITH THE 24-INCH REFRACTOR OF THE LOWELL OBSERVATORY,

By T. J. J. SEE.

Since the establishment of the observatory in Mexico, we have resumed our sweeps for southern double stars, with the result of finding a number of objects of great interest. As the latter part of the night has been devoted to the double star work, our sweeps have been confined chiefly to the constellations *Puppis*, *Carina*, *Vela*, *Crux* and *Centaurus*. On a few evenings some time has been available for hurried sweeps over the bright stars in *Phœnix*, *Eridanus* and *Dorado*. Three of the objects recently discovered are of particular interest, and may properly be regarded as among the most splendid systems in the heavens. These systems are:

(1). *α Phœnicis*, discovered 1897 Jan. 10.

The position of this star is:

$\alpha = 0^h\ 21^m\ 19^s.5$; $\delta = -42^\circ\ 50'\ 48''.1$ (1900).

The companion is of the 13th magnitude, and purplish in color. According to the *Uranometria Argentina*, *α Phœnicis* is of the 2.4 magnitude; so great an inequality in brightness combined with the well known deep orange or reddish color of *α Phœnicis*, renders the system both very striking and very difficult. Though our measures have been made when the star was several hours west of the meridian, and therefore under some difficulty, owing to the low altitude, there is reason to think that the mean position is essentially correct. We find by the settings of the micrometer:

t	θ_0	ρ_0	Mags.	Remarks
	°	″		
1897.028	287.8*	9.68	2 : 13.5	certainly real
1897.030	275.5	9.57	2 : 13	clear at moments
1897.036	269.8	10.57	2.5 : 13	
1897.039	266.0	10.64	2.5 : 13	
1897.046	269.3	9.60	2 : 13	
1897.071	268. ±	9.40	2 : 13	difficult
1897.041	272.7	9.73	2.2 : 13.1	

* This angle is so inconsistent with the estimate of 265°, and with subsequent measures, that I suspect a mistake in reading the circle.

(2). *μ Velorum*, discovered 1897 Jan. 10.

This star has a magnitude of 2.9; its companion about 11, purplish, and very close to the large star. The position of *μ Velorum* is

$$\alpha = 10^h\,42^m\,27^s.9 \quad : \quad \delta = -48^\circ\,53'\,31''.1 \;\; (1900).$$

Though the object is easy with the large telescope, the great inequality in brightness would render it difficult for an inferior glass, especially if the atmospheric conditions were not of the very best. The system is one of the most extraordinary in the heavens, and is almost certain to have rapid orbital motion. Our measures of the companion are as follows:

t	θ_0	ρ_0	Mags.	Remarks
1897.025	65.8	2.59	2.5 : 11	good measures
1897.041	59.6	2.91	2.5 : 11	blurred
1897.085	62.6	2.18	2.5 : 10	good images
1897.086	63.0	2.38	3 : 10.5	good measures
1897.059	62.7	2.54	2.6 : 10.6	

Mr. Cogshall:

1897.085	63.0	2.24	3 : 9

(3). *η Centauri*, discovered 1897 Jan. 11.

$$\alpha = 11^h\,29^m\,10^s.3 \quad : \quad \delta = -41^\circ\,42'\,59''.6 \;\; (1900).$$

Magnitudes, 2.5; 13.5; colors, yellow, purplish.

This object is extremely difficult, and can be seen only with a powerful telescope; it is certainly a physical system, and will possess the highest interest.

t	θ_0	ρ_0	Mags.	Remarks
1897.028	270 ±	6.0 ±	2.5 : 13.5	very difficult
1897.041	261.4	5.57	2.5 : 13.5	
1897.085	276.0	5.38	2.9 : 13.5	
1897.051	270.1	5.65	2.6 : 13.5	

Lowell Observatory, City of Mexico, Mexico, 1897 *Feb.* 2.

REVISED ELEMENTS OF 320 *U CEPHEI*,

By S. C. CHANDLER.

The elements of this star given in the Second and Third Catalogues have been recently revised by means of the minima observed by **Yendell** and J. A. **Parkhurst** during the past four years. The revised elements are:

$$1880 \text{ June } 23^d\,9^h\,39^m.6 \text{ (Gr. M.T.)} \; + 2^d\,11^h\,49^m\,37^s.85\,\mathrm{E} + 130^m \sin(0^\circ.06\,\mathrm{E} + 300^\circ)$$

They indicate a larger amplitude and a longer cycle for the periodical term than the former elements gave, and satisfy all the data since 1828 entirely within the uncertainty of the observations.

For the purpose of accurate comparison of observation with the above elements the following ephemeris of minima for 1897 is given, containing the heliocentric Greenwich mean time of every tenth minimum. The intermediate ones may be interpolated directly with precision, or with sufficient approximation by means of the adjoined table of multiples of the period. The length of the period, from the above elements, for any value of E, is $2^d\,11^h\,49^m\,37^s.85 + 8^s.168 \cos(0^\circ.06\,\mathrm{E} + 300^\circ)$.

Hence for E 2120, $P = 2^d\,11^h\,49^m.644$
E 2560, $= 49\;.622$

A mean value of P for the year is used for the table of multiples.

E	Heliocentric Greenwich M.T.		d	h	m
2420	1896	Dec.	29	1	35.76
30	1897	Jan.	22	23	52.18
40		Feb.	16	22	8.57
50		Mar.	13	20	24.96
60		Apr.	7	18	41.34
70		May	2	16	57.70
80			27	15	14.04
2490		June	21	13	30.37
2500		July	16	11	46.68
10		Aug.	10	10	2.98
20		Sept.	4	8	19.27
30			29	6	35.55
40		Oct.	24	4	51.81
50		Nov.	18	3	8.05
60		Dec.	13	1	24.27
2570			37	23	40.49

Multiples of Period		d	h	m
1	Per. =	2	11	49.63
2	“	4	23	39.27
3	“	7	11	28.90
4	“	9	23	18.53
5	“	12	11	8.17
6	“	14	22	57.80
7	“	17	10	47.43
8	“	19	22	37.06
9	“	22	10	26.70
10	“	24	22	16.33

OBSERVATIONS OF VARIABLE STARS IN 1896.

By WALTER J. GILL, Jr.

4521. *R Virginis.*

Twelve observations of this star, made between May 13 and Aug. 11, inclusive, indicate a minimum June 4. As I have no reliable magnitudes of the comparison-stars, the light is not given.

4557. *S Ursae Majoris.*

From Mar. 31 to Aug. 12, I have twenty-four observations, indicating a maximum of $8^M.6$, June 16. Its light at the first observation was $9^M.8$, at the last about $10^M.0$.

4816. *V Virginis.*

Six observations, from June 4 to July 18, yield a maximum June 23. The observations being few the curve is somewhat uncertain.

4847. *S Virginis.*

A maximum of $6^M.7$ is indicated on June 6, by twenty-one observations from April 15 to Aug. 11. Its light at the first observation was $9^M.2$, at the last $8^M.5$. The increase was more rapid than the decrease.

5194. *V Bootis.*

Sixteen observations of the above star, beginning June 3 with the variable about $8^M.2$, and ending Oct. 27, when it was $8^M.7$, indicate a maximum of $7^M.5$ July 23.

5501. *S Serpentis.*

Seventeen observations, from May 12 to Aug. 19, indicate a maximum of $7^M.6$ on June 19. Its light at the first observation was about $9^M.7$, at the last about $9^M.6$.

5675. *V Coronae.*

Observations of this star began April 15, when it was about $9^M.0$. It rose to a maximum of $8^M.5$ May 23, and then fell till it was about $9^M.5$ July 16, after which it remained nearly stationary during the rest of the time it was under observation. The nineteenth and last observation was on Aug. 29.

5955. *R Draconis.*

I have fifteen observations, from Aug. 11 to Dec. 5. Its light was about $9^M.5$ on both of the above dates. A maximum of $6^M.8$ is indicated on Sept. 24. The increase was much more rapid than the decrease.

6512. *T Herculis.*

Observed this star eleven times. On June 27 it was about $9^M.6$, increasing gradually till on July 16 it was about $9^M.5$. It then rose rapidly to a maximum of $8^M.1$, Aug. 10, after which it decreased slowly until the last observation Oct. 7, when it was $9^M.5$.

6636. *U Sagittarii.*

Twenty-four observations of this short-period variable, from July 11 to Oct. 7, give the following maxima and minima:

Maxima		Minima	
July 13.57	Aug. 29.33	July 17.84	Aug. 22.02
Aug. 9.39	Sept. 11.42	26.03	Sept. 1.10
17.35	20.29	Aug. 7.81	10.13
24.60	26.83	14.17	24.09
			Oct. 7.35

6733. *R Scuti.*

I made twenty-six observations of this star. At the first, on June 19, it was $5^M.7$. It then decreased to a minimum of $7^M.5$, July 22, after which it rose steadily to a maximum of $5^M.2$, Sept. 4.

After passing the maximum the light-curve shows a bright minimum of about $6^M.0$, Oct. 5, and a faint maximum of $5^M.6$, Oct. 25. After this, twilight and low altitude made the observations somewhat uncertain; but they seem to indicate a slow decrease.

7085. *RT Cygni.*

A maximum of $7^M.3$ is indicated on July 12, by twenty observations, from May 19 to Sept. 20. Its light on the first named date was about $10^M.3$; on the last about the same.

7560. *R Vulpeculae.*

I have ten observations, from Oct. 3 to Dec. 5. A maximum of $8^M.2$ is indicated on Nov. 6. Its light at both first and last observations was about $9^M.7$. The light-curve is very regular, with about equal times of increase and decrease.

Roxbury, Mass., 1897 *Feb.* 1.

REQUEST FOR MERIDIAN-OBSERVATIONS.

Prof. C. L. **Doolittle** of the University of Pennsylvania, Philadelphia, desires meridian-observations of the following stars from his latitude list; and requests that observers may obligingly favor him with preliminary or other results in advance of publication.

	Mag.	α 1897 h m s	δ 1897 ° ′
DM. 61°1381	7.5	13 46 43	+61 1.9
37 2545	6.8	14 29 8	+37 24.9
41 2539	6.8	14 52 7	+41 33.1
49 2583	5.8	17 2 6	+43 56.8
43 2711	neb.	17 13 58	+43 14.9
39 3147	6.5	17 27 14	+38 57.6
51 3324	7.5	22 14 39	+52 8.4

OBSERVATIONS AND PERIOD OF 3495 *l CARINAE*,

By R. T. A. INNES.

[Communicated by Dr. Gill, H. M. Astronomer.]

This star has been continuously observed during 1896, and some interesting features of its variation brought to light.

In the annexed table the dates of maximum and minimum which I have access to are given, including my recent observations. The first three are to be found in the "*Uranometria Argentina*," the following fifteen (to February 1896) in the publications of the British Astronomical Association, the remainder are now published for the first time. The column headed O−C is the difference between observation and maxima calculated from the elements, 1871 July 24.9+$35^d.5236$ E.

Date	Observer	Phase and Mag.		O—C
				d
1871 July 31	Cordoba	*M*		+4.3
Aug. 31	"	*M*		—0.2
1872 May 7	"	*M*		+1.1
1891 Apr 23	Roberts	*M*	3.30	+2.5
July 28	"	*m*	5.30	
1892 May 18	"	*M*	3.30	+2.3
July 18	"	*m*	5.50	
1895 Jan. 27	Innes	*m*	4.80	
Feb. 10	"	*M*	3.68	+1.6
Mar. 2	"	*m*	4.53	
11	"	*M*	3.50	—1.9
31	"	*m*	4.50	
Apr. 21	"	*M*	3.55	+1.5
Dec. 12	"	*m*	4.72	
25	"	*M*	3.56	+0.9
1896 Jan. 17	"	*m*	4.36	
28	"	*M*	3.50	—0.6
Feb. 19	"	*m*	4.58	
Apr. 8	"	*M*	3.38	—0.7
May 5	"	*m*	4.40	
14	"	*M*	3.40	—0.2
June 7	"	*m*	4.70	
19	"	*M*	3.64	+0.3
July 13	"	*m*	4.70	
25	"	*M*	3.48	+0.7
Oct. 31	"	*m*	4.90	
Nov. 6	"	*M*	3.48	—1.8
Dec. 3	"	*m*	4.80	
12	"	*M*	3.63	—1.4

The observations made in 1895 and 1896 were plotted and the data in the above table taken from the best curve drawn through the observations. Details of these observations will be published in due course.

In the above table the dates of the chief maximum and minimum only are recorded; there is a secondary maximum which is well shown in the observations from 1896 April 10 to May 16, as follows:

	M		M		M
Apr. 10	3.35	Apr. 21	4.3	May 6	4.4
11	3.7	22	4.2	7	4.1
13	3.8	25	4.2	9	4.0
14	3.8	26	4.2	10	3.9
15	4.0	27	4.1	12	3.7
16	4.0	28	4.0	13	3.6
18	4.2	29	4.1	14	3.4
19	4.3	30	4.3	16	3.6
20	4.3	May 4	4.1		

On other occasions the secondary maximum has not been so marked in character, sometimes degenerating to a halt in the passage to the chief minimum. From the chief minimum to the chief maximum the interval varies from 6 to 21 days, the average being $13^{d}.4$. The range of magnitude is from $3^{M}.30$ to $5^{M}.50$, according to Mr. A. W. ROBERTS's observations, whilst I find $3^{M}.38$ to $4^{M}.90$.

The residuals in the column O—C show a variation in the period amounting to about 2 days above and below the mean period. It will be also noticed that the brightness at maximum and minimum varies in a series.

The elements given by Dr. CHANDLER in his Third Catalogue are at present about a fortnight in error.

Royal Observatory, Cape of Good Hope, 1896 December.

NEW ASTRONOMICAL WORK.

Veröffentlichungen der Grossherzoglichen Sternwarte zu Karlsruhe; Fünftes Heft. Dr. W. VALENTINER.

With this volume closes the published series of observations undertaken at the Grand-Ducal Observatory of Baden for the determination of the positions of all stars to the eighth magnitude which are included between the parallels of 0° and —8° of declination. The instrument with which these observations were made was originally a Reichenbach "*Multiplicationskreis*," first set up in 1811 at Mannheim. It had long figured as a museum-exhibit of historic interest, when Dr. VALENTINER, under conditions of strictest economy, conceived the idea of converting it into a meridian circle. The objective of the telescope is of 84 mm. aperture, and the circle is a little more than 0.9 m. in diameter.

In the introduction of this fifth number of the publications of the Karlsruhe Observatory are exhibited the results of an extended examination of the error of graduation, for every degree throughout the circle, and for each graduation mark within the limits employed in observation. From the latter section of the investigation it is shown that there is a well marked systematic error in the subdivisions of a degree amounting to 0″.5 or more in three instances out of nineteen, and to 0″.26 in the mean.

The present volume contains about 8300 observations reduced to 1885, of which about one in four are of the stars considered as standard. The final catalogue will contain about 16,200 observations of 2700 stars, — three in each position of the circle for each star.

Dr. VALENTINER notes that, besides these meridian observations, during the period from 1892 to 1896 July 1, a continuous series of latitude-determinations by the Talcott method has been kept up at Karlsruhe, and that observations of 5949 pairs of stars on 639 evenings are contained in the records of this undertaking.

This volume marks the close of the establishment at Karlsruhe, transferred from Mannheim sixteen years ago, and now transferred to Heidelberg. In the new location this observatory is to be associated with a separate astro-physical establishment; and its means for observation will be greatly enlarged, to include, among other new instruments, a meridian-circle by REPSOLD. L. B.

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MEASURES OF DOUBLE STARS,

MADE AT THE LICK OBSERVATORY OF THE UNIVERSITY OF CALIFORNIA,

BY WILLIAM J. HUSSEY.

1. Σ3062.

$\alpha = 0^{h}\,1^{m}\,2^{s}$, $\delta = +57^{\circ}\,52'.7$

	°	″
1896.655	335.2	1.59
.733	334.4	1.50
.736	335.9	1.51
.869	336.9	1.50
1896.75	335.6	1.53

2. Σ15.

$\alpha = 0^{h}\,10^{m}\,44^{s}$, $\delta = -6^{\circ}\,9'.4$

1896.869	198.1	4.74

3. OΣ12.

$\alpha = 0^{h}\,26^{m}\,15^{s}$, $\delta = +53^{\circ}\,58'.2$

1896.869	150.1	0.59
.872	147.0	0.70
1896.87	148.6	0.65

4. Σ52.

$\alpha = 0^{h}\,38^{m}\,38^{s}$, $\delta = +45^{\circ}\,41'.3$

1896.872	14.8	1.41

5. *η Cassiopeae.*

$\alpha = 0^{h}\,43^{m}\,3^{s}$, $\delta = +57^{\circ}\,17'.1$

1896.869	208.6	5.08
.872	207.5	5.29
.941	209.8	5.04
1896.89	208.6	5.14

6. β735.

$\alpha = 0^{h}\,59^{m}\,50^{s}$, $\delta = -34^{\circ}\,4'.1$

1896.869	220.0	8.13

7. OΣ28.

$\alpha = 1^{h}\,9^{m}\,40^{s}$, $\delta = +80^{\circ}\,20'.0$

1896.869	308.0	0.86
.872	316.0	0.74
1896.87	312.0	0.80

8. OΣ65.

$\alpha = 3^{h}\,44^{m}\,18^{s}$, $\delta = +25^{\circ}\,16'.7$

1896.869	202.3	0.62
.878*	198.2	0.61
.943	197.0	0.57
1896.90	199.5	0.60

9. β552.

$\alpha = 4^{h}\,46^{m}\,11^{s}$. $\delta = +13^{\circ}\,29'.2$

	°	″
1896.839	187.7	0.43

10. *Sirius.*

$\alpha = 6^{h}\,40^{m}\,44^{s}$, $\delta = -16^{\circ}\,34'.7$

See notes.

11. OΣ175.

$\alpha = 7^{h}\,28^{m}\,48^{s}$, $\delta = +31^{\circ}\,10'.7$

1896.869	329.0	1.00

12. *ζ Cancri.*

$\alpha = 8^{h}\,6^{m}\,29^{s}$, $\delta = +17^{\circ}\,57'.0$

1896.869	15.0	1.20 *AB*
.869	116.2	5.41 *AC*

13. *ω Leonis.*

$\alpha = 9^{h}\,23^{m}\,6^{s}$, $\delta = +9^{\circ}\,29'.5$

1896.869	109.8	0.88
97.066	109.4	0.91
.072*	110.3	0.90
1897.00	109.8	0.90

14. *ξ Ursae Majoris.*

$\alpha = 11^{h}\,12^{m}\,51^{s}$, $\delta = +32^{\circ}\,5'.5$

1896.513	167.6	2.01

15. *γ Virginis.*

$\alpha = 12^{h}\,36^{m}\,36^{s}$, $\delta = -0^{\circ}\,54'.1$

1896.481	329.6	5.85
.483	328.8	5.74
.503	331.3	6.18
1896.49	329.9	5.92

16. *Mizar.*

$\alpha = 13^{h}\,19^{m}\,54^{s}$, $\delta = +55^{\circ}\,26'.9$

1896.475	149.2	14.64
.485	148.6	14.39
.513	149.4	14.56
1896.49	149.1	14.53

17. *ε Bootis.*

$\alpha = 14^{h}\,40^{m}\,37^{s}$, $\delta = +27^{\circ}\,29'.8$

	°	″
1896.366	330.9	3.14
.450	332.7	2.75
.478	330.0	2.73
.483	329.6	2.70
1896.46	330.8	2.84

18. *ξ Bootis.*

$\alpha = 14^{h}\,46^{m}\,47^{s}$. $\delta = +19^{\circ}\,31'.0$

1896.450	224.7	2.96
.478	220.8	2.95
.481	222.1	2.85
.483	223.5	3.04
1896.47	222.8	2.95

19. Σ1909.

$\alpha = 15^{h}\,0^{m}\,30^{s}$, $\delta = +48^{\circ}\,2'.6$

1896.450	242.9	5.02
.475	243.6	4.75
.481	242.9	4.83
.483	242.8	4.67
1896.47	243.1	4.82

20. Σ1910.

$\alpha = 15^{h}\,2^{m}\,43^{s}$, $\delta = +9^{\circ}\,36'.6$

1896.475	212.4	4.27
.481	211.2	4.89
.483	211.5	4.49
1896.48	211.7	4.55

21. *η Coronae Bor.*

$\alpha = 15^{h}\,19^{m}\,4^{s}$, $\delta = +30^{\circ}\,38'.9$

1896.602*	318.9	0.30 *a*
.650*	317.5	0.32 *b*
1896.65	318.2	0.31

22. Σ1956.

$\alpha = 15^{h}\,29^{m}\,44^{s}$, $\delta = +42^{\circ}\,8'.6$

1896.513	39.4	2.19
.640	41.5	2.39
1896.58	40.4	2.29

23. *δ Serpentis.*

$\alpha = 15^{h}\,30^{m}\,2^{s}$, $\delta = +10^{\circ}\,52'.4$

	°	″
1896.450	186.4	3.59
.464	185.1	3.47
.481	186.0	3.61
.503	186.8	3.10
.511	186.2	3.56
1896.48	186.1	3.47

24. Σ1961.

$\alpha = 15^{h}\,31^{m}\,10^{s}$, $\delta = +43^{\circ}\,51'.5$

1896.513	41.0	23.29

25. OΣ299.

$\alpha = 15^{h}\,32^{m}\,24^{s}$, $\delta = +64^{\circ}\,4'.3$

1896.513	23.0	3.57

26. OΣ298.

$\alpha = 15^{h}\,32^{m}\,30^{s}$, $\delta = +40^{\circ}\,7'.9$

1896.513	173.9	1.05 *AB*

27. Σ1985.

$\alpha = 15^{h}\,50^{m}\,44^{s}$, $\delta = -1^{\circ}\,52'.2$

1896.464	336.7	5.88
.478	337.0	5.81
.481	336.2	5.69
1896.47	336.6	5.79

28. *ξ Scorpii.*

$\alpha = 15^{h}\,58^{m}\,52^{s}$, $\delta = -11^{\circ}\,5'.8$

1896.486*	37.9	0.98 *AB*
.489*	34.6	0.99
1896.49	36.2	0.99
1896.464	38.3	1.05
.481	34.6	0.88
.483	31.5	0.98
1896.47	34.8	0.97
1896.464	64.8	7.30 *AB*
.481	62.7	7.42 &
.483	62.1	7.62 *C*
1896.47	63.2	7.45

29. Σ1999.

$\alpha = 15^h\ 58^m\ 56^s$, $\delta = -11^\circ\ 10'.4$

		″
1896.464	101.6	11.04
.481	100.4	11.20
.483	100.1	11.06
1896.48	100.7	11.10

30. *β Scorpii.*

$\alpha = 15^h\ 59^m\ 37^s$, $\delta = -19^\circ\ 31'.9$

1896.483	25.4	13.79 *AC*
.514	25.2	13.66
.579*	25.4	13.34
1896.53	25.3	13.60

31. *ω¹ Scorpii.*

$\alpha = 16^h\ 0^m\ 58^s$, $\delta = -20^\circ\ 23'.9$

1896.514	48.1	2.15
.640	46.4	2.28
1896.58	47.3	2.22

32. *ω² Scorpii.*

$\alpha = 16^h\ 1^m\ 32^s$, $\delta = -20^\circ\ 35'.9$

1896.514	3.5	1.15

33. Σ2022.

$\alpha = 16^h\ 8^m\ 38^s$, $\delta = +26^\circ\ 55'.6$

1896.640	140.6	2.72

34. 49 F *Serpentis.*

$\alpha = 16^h\ 8^m\ 39^s$, $\delta = +13^\circ\ 47'.7$

1896.640	332.3	3.91

35. *σ Scorpii.*

$\alpha = 16^h\ 15^m\ 6^s$, $\delta = -25^\circ\ 21'.2$

1896.472	272.0	20.69
.514	272.1	20.53
1896.49	272.1	20.61

36. *Antares.*

$\alpha = 16^h\ 23^m\ 16^s$, $\delta = -26^\circ\ 12'.7$

1896.448*	275.7	3.28
.472*	276.3	3.05
.476*	275.6	3.28
1896.47	275.9	3.20
1896.481	271.5	3.14
.483	273.7	3.04
1896.48	272.6	3.09

37. *λ Ophiuchi.*

$\alpha = 16^h\ 25^m\ 52^s$, $\delta = +2^\circ\ 12'.2$

1896.511	51.5	1.88
.514	49.2	1.45
.582	51.4	2.05
1896.54	50.7	1.79

38. Σ2120.

$\alpha = 17^h\ 0^m\ 48^s$, $\delta = +28^\circ\ 13'.7$

1896.462	244.3	7.15
.503	243.4	7.42
.511	245.8	7.23
1896.49	244.5	7.27

39. Σ2119.

$\alpha = 17^h\ 0^m\ 50^s$, $\delta = -13^\circ\ 47'.9$

		″
1896.503	14.3	2.21
.640	13.8	2.28
1896.57	14.0	2.25

40. β282.

$\alpha = 17^h\ 8^m\ 34^s$, $\delta = -14^\circ\ 28'.1$

1896.503	155.4	4.29
.640	152.0	4.27
1896.57	153.7	4.28

41. *α Herculis.*

$\alpha = 17^h\ 10^m\ 5^s$, $\delta = +14^\circ\ 30'.2$

1896.162	114.5	4.94
.503	113.7	4.64
.511	112.2	4.89
1896.49	113.5	4.82

42. Σ2192.

$\alpha = 17^h\ 29^m\ 53^s$, $\delta = +6^\circ\ 4'.3$

1896.638	64.3	11.13

43. Σ2185.

$\alpha = 17^h\ 29^m\ 55^s$, $\delta = +6^\circ\ 5'.6$

1896.475	5.2	28.13
.640	4.1	27.50
1896.56	4.7	27.82

44. Σ2190.

$\alpha = 17^h\ 31^m\ 43^s$, $\delta = +21^\circ\ 3'.7$

1896.475	22.7	10.63
.638	23.6	10.60
1896.56	23.2	10.62

45. Σ2202.

$\alpha = 17^h\ 39^m\ 33^s$, $\delta = +2^\circ\ 37'.3$

1896.629	92.9	20.65
.638	93.3	20.67
1896.63	93.1	20.66

46. Σ2218.

$\alpha = 17^h\ 39^m\ 40^s$, $\delta = +63''\ 43'.1$

1896.462	344.9	2.31
.503	345.5	2.19
.511	344.5	2.07
1896.49	345.0	2.19

47. Σ2213.

$\alpha = 17^h\ 41^m\ 4^s$, $\delta = +31^\circ\ 10'.4$

1896.629	331.5	4.59
.638	331.0	4.58
1896.63	331.2	4.59

48. *τ Ophiuchi.*

$\alpha = 17^h\ 57^m\ 38^s$, $\delta = -8^\circ\ 10'.8$

1896.374	256.8	1.94
.462	257.3	2.23
.464	254.4	1.90
1896.43	256.2	2.02

49. 70 *Ophiuchi.*

$\alpha = 18^h\ 0^m\ 24^s$, $\delta = +2^\circ\ 31'.4$

		″
1896.152*	293.9	2.21
.251*	292.5	2.24
.333*	292.8	2.27
.432*	292.3	2.03
.448*	292.0	2.27
.738*	290.1	2.12
1896.39	292.3	2.19

50. Σ2277.

$\alpha = 18^h\ 0^m\ 32^s$, $\delta = +48^\circ\ 27'.6$

1896.503	121.4	27.30
.629	120.8	27.27
1896.57	121.1	27.28

51. *ε Lyrae.*

$\alpha = 18^h\ 41^m\ 2^s$, $\delta = +39^\circ\ 33'.9$

1896.638	14.9	3.09
.735	14.1	3.19
.744	14.0	3.09
1896.71	14.3	3.12

52. 5 *Lyrae.*

$\alpha = 18^h\ 41^m\ 4^s$, $\delta = +39^\circ\ 30'.5$

1896.638	132.3	2.21
.735	129.9	2.19
.744	131.6	2.26
1896.71	131.3	2.12

53. *ο Draconis.*

$\alpha = 18^h\ 49^m\ 43^s$, $\delta = +59^\circ\ 15'.9$

1896.494	335.2	32.05
.503	334.9	31.91
.638	334.9	32.02
1896.54	335.0	32.00

54. Σ2441.

$\alpha = 18^h\ 58^m\ 52^s$, $\delta = +31^\circ\ 15'.2$

1896.503	279.2	5.41
.511	278.5	5.48
1896.51	278.9	5.44

55. Σ2484.

$\alpha = 19^h\ 9^m\ 52^s$, $\delta = +18^\circ\ 53'.5$

1896.735	230.7	2.61
.744	228.9	2.59
1896.74	229.8	2.60

56. *β Cygni.*

$\alpha = 19^h\ 26^m\ 41^s$, $\delta = +27^\circ\ 45'.0$

1896.456	55.7	34.63
.494	55.1	34.70
.503	55.6	34.84
.507	55.4	34.60
1896.49	55.5	34.69

57. *O*Σ383.

$\alpha = 19^h\ 39^m\ 32^s$, $\delta = +40^\circ\ 29'.0$

1896.733	18.4	0.86
.941	19.2	0.82
1896.81	18.8	0.84

58. *δ Cygni.*

$\alpha = 19^h\ 41^m\ 51^s$, $\delta = +44^\circ\ 53'.2$

	°	″
1896.503	304.8	1.67
.638	306.0	1.55
.733	303.6	1.58
.744	302.1	1.67
.850	305.5	1.68
1896.69	304.4	1.63

59. *O*Σ385.

$\alpha = 19^h\ 42^m\ 24^s$, $\delta = +40^\circ\ 18'.6$

1896.733	57.3	1.31
.941	54.8	1.23
1896.84	56.1	1.27

60. *O*Σ386.

$\alpha = 19^h\ 44^m\ 39^s$, $\delta = +36^\circ\ 54'.7$

1896.735	77.2	1.03
.738*	77.1	1.01
1896.74	77.2	1.02

61. *O*Σ387.

$\alpha = 19^h\ 45^m\ 0^s$, $\delta = +35^\circ\ 3'.5$

1896.738*	344.6	0.46

62. Σ2609.

$\alpha = 19^h\ 54^m\ 58^s$, $\delta = +37^\circ\ 50'.9$

1896.733	27.4	2.13
.736	25.3	2.07
.738*	27.0	2.01
1896.74	26.6	2.14

63. *O*Σ400.

$\alpha = 20^h\ 6^m\ 54^s$, $\delta = +43^\circ\ 38'.8$

1896.878*	64.8	est.<0.2
.926*	70.8	0.18
1896.90	67.8	0.18

64. *β Delphini.*

$\alpha = 20^h\ 32^m\ 52^s$, $\delta = +14^\circ\ 14'.8$

1896.828*	352.8	0.63
.869	356.1	0.56
.875	356.5	0.61
1896.86	335.1	0.60

65. *O*Σ414.

$\alpha = 20^h\ 43^m\ 34^s$, $\delta = +42^\circ\ 2'.5$

1896.744	95.0	10.25
.941	94.9	9.84
1896.84	95.0	10.05

66. *O*Σ416.

$\alpha = 20^h\ 48^m\ 50^s$, $\delta = +43^\circ\ 22'.8$

1896.655	136.0	7.59
.735	135.2	7.57
.746	134.7	7.55
1896.71	135.3	7.57

67. Σ2741.

$\alpha = 20^{h} 55^{m} 18^{s}$, $\delta = +50^{\circ} 4'.4$

	°	″
1896.374	31.4	1.87
.655	30.8	1.87
.733	31.2	1.87
.744	31.3	1.84
1896.63	31.2	1.86

68. Σ2746.

$\alpha = 20^{h} 57^{m} 59^{s}$, $\delta = +38^{\circ} 52'.1$

1896.733	292.1	1.12
.744	292.4	1.01
.869	292.4	0.91
1896.78	292.3	1.01

69. 61 *Cygni.*

$\alpha = 21^{h} 2^{m} 25^{s}$, $\delta = +38^{\circ} 15'.4$

1896.377	124.4	22.33
.746	124.0	21.92
1896.56	124.2	22.12

70. OΣ432.

$\alpha = 21^{h} 10^{m} 29^{s}$, $\delta = +40^{\circ} 43'.9$

1896.733	126.6	1.24
.744	128.0	1.29
1896.74	127.3	1.26

71. τ *Cygni.*

$\alpha = 21^{h} 10^{m} 48^{s}$, $\delta = +37^{\circ} 37'.1$

1896.733	333.0	0.84
.738*	328.2	0.54
.856	330.4	0.84
.869	335.6	0.65
.875	337.0	0.68
.878*	328.1	0.86
1896.82	332.1	0.73

72. Σ2783.

$\alpha = 21^{h} 11^{m} 21^{s}$, $\delta = +57^{\circ} 53'.0$

	°	″
1896.878*	30.3	1.04
.924*	28.6	1.18
1896.90	29.5	1.11

73. 29 *Pegasi.*

$\alpha = 21^{h} 28^{m} 21^{s}$, $\delta = +20^{\circ} 16'.2$

1896.655	333.0	3.14
.735	332.6	2.97
.744	332.5	2.90
.746	333.1	3.02
1896.72	332.8	3.01

74. DM. –20°6313.

$\alpha = 21^{h} 48^{m} 12^{s}$, $\delta = -20^{\circ} 29'.0$

1896.368*	73.7	5.32
.382*	74.6	5.77
.602*	73.3	5.62
.640	74.1	5.71
.806	74.5	5.54
1896.56	74.0	5.59

75. 29 *Aquarii.*

$\alpha = 21^{h} 56^{m} 58^{s}$, $\delta = -17^{\circ} 26'.8$

1896.640	63.1	3.96
.806	64.1	3.87
1896.72	63.6	3.92

76. Anonymous.

$\alpha = 22^{h} 3^{m}$, $\delta = -19^{\circ} 28'$

1896.462	112.5	3.39
.626	110.8	3.35
.640	112.4	3.36
.806	113.1	3.42
1896.63	112.2	3.34

77. β170.

$\alpha = 22^{h} 3^{m} 35^{s}$, $\delta = -18^{\circ} 58'.3$

		″
1896.640	60.9	1.55
.806	57.0	1.29
1896.72	59.0	1.42

78. 53 *Aquarii.*

$\alpha = 22^{h} 21^{m} 9^{s}$, $\delta = -17^{\circ} 15'.0$

1896.463	309.5	7.23
.503	308.1	7.58
.626	308.6	7.22
1896.55	308.7	7.34

79. Σ2909.

$\alpha = 22^{h} 23^{m} 41^{s}$, $\delta = -0^{\circ} 31'.9$

1896.655	322.5	3.35
.733	320.6	3.28
.735	320.6	3.35
1896.71	321.2	3.33

80. S.DM. –19°6291

$\alpha = 22^{h} 25^{m} 27^{s}$, $\delta = -19^{\circ} 41'.8$

1896.448*	170.2	1.36
.486*	169.5	1.41
1896.47	169.8	1.38

81. Σ2958.

$\alpha = 22^{h} 51^{m} 51^{s}$, $\delta = +11^{\circ} 18'.9$

1896.856	11.2	4.00
.929	11.4	3.83
.941	11.3	3.79
1896.91	11.3	3.87

82. OΣ536.

$\alpha = 22^{h} 53^{m} 30^{s}$, $\delta = +8^{\circ} 49'.6$

	°	″
1896.974*	162.5	0.29

83. OΣ483.

$\alpha = 22^{h} 54^{m} 12^{s}$, $\delta = +11^{\circ} 11'.6$

1896.655	217.8	0.86
.735	223.3	1.05
.856	223.2	0.94
.869	223.6	1.10
1896.78	222.0	0.99

84. 96 *Aquarii.*

$\alpha = 23^{h} 14^{m} 13^{s}$, $\delta = -5^{\circ} 40'.2$

1896.935*	20.2	10.52
.938*	23.2	10.68
1896.94	21.7	10.60

85. 85 *Pegasi.*

$\alpha = 23^{h} 56^{m} 57^{s}$, $\delta = +26^{\circ} 33'.2$

1896.803*	210.2	0.47
.926*	206.9	0.72
1896.86	208.6	0.60

86. Σ3057.

$\alpha = 23^{h} 59^{m} 45^{s}$, $\delta = +57^{\circ} 58'.5$

1896.933	298.8	3.77
.936	299.2	3.82
1896.73	299.0	3.80

NOTES.

Most of the above observations have been made with the 12-inch telescope; those made with the 36-inch are indicated by a * following the date of observation. A power of 545 was used on the 12-inch for all measures made before 1896.8, and one of about 700 for all made after that date. Powers of 1000 and 1500 have generally been used on the 36-inch. In general each angle is derived from the mean of four settings of the circle, and each distance from the mean of four double distances. Precautions have always been taken to render the different settings independent. Both telescopes have been so nearly in adjustment that corrections for azimuth and inclination of polar axis are insensible. The driving clock of the 12-inch has given more or less trouble all along, and on this account it has been difficult to obtain thoroughly satisfactory measures of distance of stars having position-angles in the neighborhood of 90° or 270°.

The positions given in the above list are for 1900. In addition we have the following notes to the several stars as indicated by their current numbers above:

1. Binary; $6^{M}.8$, $7^{M}.8$. 2. No change since 1830. 3. Change since 1844, +26°, 0″.0. 4. Change since 1831, —11°, 0″.0. 5. Binary. 8. Binary; special effort made to determine the correct quadrant. 9. Single in 1892; binary. 10. Examined *Sirius* carefully with the 36-inch on 5 nights in February and March, 1896, without seeing the companion. Seeing good on 4 of the nights. The micrometer-wire was set to ephemeris-place, 194°, 4″.2, and entire region thereabouts examined. On the last two nights each eyepiece was provided with a diaphragm, accurately at its focus, covering half the field of view. On these nights, after I had finished my search, Prof. CAMPBELL also examined *Sirius* carefully, but did not see the companion. 11. Change since 1843, —5°, +0″.5. 13. Period about 114 years. 14. Binary. 15. Binary. 17. Change since Σ in 1828, +8°, 0″.0. 18. Binary. 19. Binary. 20. Change since 1823 very small, if any. 21. *a*, power 1500; *b*, power 1000. 22. Change since 1831, —0″.4. 23. Change since 1821, —11°, +0″.5±. 24. Change since 1830, —15°, +1″.7. 27. Change since 1830, +11°, —1″.2. 29. Change since 1836, —2°, +0″.4. 33. Change since 1830, +11°, 0″.0. 40. No change. 41. Change since 1822, —6°. 42. Change since 1832, —24°, +0″.8. 43. No motion since 1830. 44. Change since 1830, —9°. 45. No change since 1827. 46. Change since 1831, —15°, —0″.6. 47. Binary. 49. No other companion seen. 50. Change since 1830 slight. 51. Binary. 52. Binary. 53. *o Draconis* = Σ2420. Change since 1780, —25°, +5″.3. Motion rectilinear. 54. Change

since 1830, −13°, +0″.25. 55. Change since 1831, +8°. 57. Change since 1843, −7°. 58. Not an easy star to measure. Mags. 3 and 8. 59. No change since 1845. 60. No change since 1846. 61. Rapid motion. 62. No change since 1830. 63. 1896.878 distance estimated <0″.2: 1896.926 distance estimated 0″.10 0″.15. 64. 1896.828, 36-inch telescope; no other companion visible; seeing good. 65. Increase of distance. 66. Change since 1846, −11°, 0″.6. 67. Change, if any, unimportant. 71. Binary. 73. Change since 1825, +20°. 76. Mags. 9.5 and 9.7. 78. Change since 1823, +8°, −1″.8. 79. Binary. 81. Change since 1831, +5°. 82. Special care taken to obtain the correct quadrant. Distance estimated 0″.25–0″.30. In 1891 Burnham's measures gave 344°.8 and 0″.15. This seems to be a very rapid binary, with the plane of the orbit nearly parallel to the line of sight. 84. 96 *Aquarii* = H 5394. Motion, if any, very slight. In 1877 Burnham estimated magnitude of companion as 14; I estimate it fully as bright as 12. The companion is decidedly red. 86. No change since 1832.

Mt. Hamilton, University of California, 1897 *Feb.* 10.

DOUBLE-STAR MEASURES,

MADE WITH THE EQUATORIAL OF THE MORRISON OBSERVATORY,

BY HENRY S. PRITCHETT.

The following measures of double stars were made with the 12½-inch equatorial of the Morrison Observatory (Glasgow, Mo.), during the summer of 1896. They are a continuation of the double-star work begun there some years ago, and described in Volume I of the publications of that observatory. A statement of the instrumental equipment and method of observing is given in that publication.

The magnifying powers employed were 300, 600 and 800, and these are distinguished in the following notes by C, D and E respectively. The four columns of the table contain the epoch of observation, the observed position-angle, the observed distance, and the magnifying power. The right-ascensions and declinations refer to the equinox of 1900.0.

Σ 1998. *ξ Scorpii, A.B.*

$\alpha = 15^h\,58^m.9$, $\delta = -11°\,5'$

		″	
1896.576	217.91	1.12	D

Σ 1998. *ξ Scorpii*, $\frac{A+B}{2}$, *C.*

1896.567	62.29	7.18	C
.576	65.16	6.90	D
1896.571	63.72	7.04	

ν Scorpii, A.B.

$\alpha = 16^h\,16^m.2$, $\delta = -19°\,12'$

1896.589	6.60	0.90	E
.603	8.23	0.87	E
1896.596	7.41	0.88	

ν Scorpii, $\frac{A+B}{2}$, $\frac{C+D}{2}$.

1896.587	337.90	40.97	C

ν Scorpii, C.D.

1896.587	50.13	2.09	C
.589	51.90	1.93	D
.603	50.90	2.25	E
1896.593	50.98	2.09	

Σ 2021.

$\alpha = 16^h\,8^m.6$, $\delta = +13°\,47'$

1896.606	333.60	3.77	E
.613	333.84	3.91	E
1896.610	333.72	3.84	

Σ 2022.

$\alpha = 16^h\,8^m.6$, $\delta = +26°\,55'$

1896.606	140.52	2.36	E
.613	133.55	2.57	E
1896.610	137.03	2.46	

Σ 2023.

$\alpha = 16^h\,9^m.6$, $\delta = +5°\,47'$

	°	″	
1896.592	228.76	1.84	C
.598	231.36	2.05	D
1896.595	230.06	1.94	

Σ 2032. *σ Coronae.*

$\alpha = 16^h\,10^m.9$, $\delta = +34°\,7'$

1896.581	210.90	4.12	D
.589	209.93	4.08	C
.595	211.10	4.06	D
1896.589	210.64	4.09	

Σ 2041.

$\alpha = 16^h\,20^m.3$, $\delta = +1°\,28'$

1896.598	4.00	2.45	D

Σ 2055. *λ Ophiuchi.*

$\alpha = 16^h\,25^m.9$, $\delta = +2°\,12'$

1896.581	48.53	1.61	D
.598	53.33	1.63	D
1896.590	50.93	1.62	

Σ 3105.

$\alpha = 16^h\,26^m.5$, $\delta = -6°\,50'$

1896.598	49.06	0.82	E

Σ 3107.

$\alpha = 16^h\,53^m.8$, $\delta = +4°\,4'$

1896.592	96.74	1.34	D
.598	95.46	1.38	D
1896.595	96.10	1.36	

Σ 2120.

$\alpha = 17^h\,0^m.8$, $\delta = +28°\,14'$

	°	″	
1896.585	244.10	6.87	D
.595	245.06	6.50	C
1896.590	244.58	6.68	

36 *Ophiuchi.*

$\alpha = 17^h\,9^m.2$, $\delta = -26°\,27'$

1896.567	192.96	4.06	C
.612	196.05	4.18	E
.632	194.93	4.04	D
1896.604	194.65	4.09	

Σ 2156.

$\alpha = 17^h\,18^m.8$, $\delta = -0°\,45'$

1896.581	36.83	3.32	D
.592	39.26	3.36	D
.595	37.00	3.28	D
1896.589	37.69	3.32	

Σ 2171.

$\alpha = 17^h\,23^m.7$, $\delta = -9°\,55'$

1896.595	68.13	1.86	
.587	67.93	. .	
1896.591	68.03	1.86	

Σ 2173.

$\alpha = 17^h\,25^m.2$, $\delta = -0°\,59'$

1896.581	160.86	1.30	D
.592	159.06	0.95	D
.598	165.23	1.42	E
1896.590	161.72	1.22	

Σ 2244.

$\alpha = 17^h\,52^m.0$, $\delta = +0°\,7'$

	°	″	
1896.581	278.23	0.94	D
.598	275.06	0.87	D
1896.590	276.65	0.91	

Σ 2220. *μ Herculis, A.B.*

$\alpha = 17^h\,42^m.5$, $\delta = +27°\,47'$

1896.581	243.28	31.93	

Σ 2220. *μ Herculis, B.C.*

1896.584	230.23	. .	D
.598	234.98	. .	E
.606	232.70	0.70	E
1896.596	232.63	0.70	

Σ 2262. *τ Ophiuchi.*

$\alpha = 17^h\,57^m.5$, $\delta = -8°\,11'$

1896.581	253.62	2.10	D
.592	258.33	1.98	D
.595	257.21	1.93	D
1896.589	256.39	2.00	

Σ 2272. 70 *Ophiuchi.*

$\alpha = 18^h\,0^m.4$, $\delta = +2°\,32'$

1896.567	290.95	2.36	C
.576	291.13	2.34	D
.581	288.16	2.11	C
.592	286.74	2.12	D
.595	288.91	1.97	D
1896.582	289.24	2.19	

Σ 2286.

$\alpha = 18^h\ 5^m.3$, $\delta = +0°\ 31'$

	°	″
1896.592	317.60	2.32 C
.595	315.20	2.14 D
1896.593	316.40	2.23

Σ 2303.

$\alpha = 18^h\ 14^m.6$, $\delta = -8°\ 3'$

1896.595	224.23	2.37 D

Σ 2306, *A.B.*

$\alpha = 18^h\ 16^m.5$, $\delta = -15°\ 8'$

	°	″
1896.606	220.25	11.54 E
.612	220.82	11.58 E
1896.609	220.54	11.56

Σ 2306, *B.C.*

1896.606	73.43	0.83 E
.612	59.08	0.81 E
1896.609	66.25	0.82

Σ 2311.

$\alpha = 18^h\ 17^m.5$, $\delta = +11°\ 23'$

	°	″
1896.598	159.06	5.64 D
.632	160.00	5.21 D
1896.615	159.53	5.43

OΣ 358.

$\alpha = 18^h\ 31^m.5$, $\delta = +16°\ 55'$

1896.612	194.37	1.93 E
.633	195.30	2.02 E
1896.622	194.83	1.98

Σ 2541.

$\alpha = 19^h\ 31^m.3$, $\delta = -10°\ 39'$

	°	″
1896.633	333.20	4.32 E

Σ 2545.

$\alpha = 19^h\ 33^m.3$, $\delta = -10°\ 23'$

1896.633	322.10	3.70 E

β 151. *β Delphini, A.B.*

$\alpha = 20^h\ 32^m.9$, $\delta = +14°\ 15'$

1896.633	1.80	0.45 E

β Delphini, A.D.

1896.633	333.00	37.23 E

Washington University, St. Louis, 1897 *Jan.* 15.

MICROMETRIC MEASURES OF DOUBLE STARS,

MADE AT THE OBSERVATORY OF WESLEYAN UNIVERSITY, MIDDLETOWN, CONNECTICUT,

By W. S. EICHELBERGER.

β795, *AC.*

$\alpha = 11^h\ 54^m$, $\delta = +71°\ 20'$

	°	″
1896.556	151.5	33.33
.595	150.4	33.47
.606	150.9	33.67
1896.586	150.9	33.49

Σ1594, *AB.*

$\alpha = 11^h\ 57^m$, $\delta = +42°\ 4'$

1896.537	157.3	15.14

Σ1594 — Cont.

	°	″
1896.606	158.5	14.99
.633	156.0	15.42
1896.592	157.3	15.18

Σ1761.

$\alpha = 13^h\ 29^m$, $\delta = +72°\ 20'$

1896.529	70.6	20.61
.597	71.2	20.66
.614	71.8	20.60
1896.580	71.2	20.62

Σ1909.

$\alpha = 15^h\ 0^m$, $\delta = +48°\ 7'$

	°	″
1896.537	243.6	4.55
.597	242.0	5.04
.614	241.6	4.67
1896.583	242.4	4.75

Σ1924.

$\alpha = 15^h\ 9^m$, $\delta = +26°\ 12'$

1896.567	305.8	15.66

Σ1924 — Cont.

	°	″
1896.606	303.6	15.57
.614	305.9	15.72
1896.596	305.1	15.65

H 577.

$\alpha = 15^h\ 52^m$, $\delta = +35°\ 51'$

1896.567	15.4	9.37
.633	15.7	9.21
1896.600	15.5	9.29

MINIMA OF THE *ALGOL*-TYPE VARIABLE 320 *U CEPHEI*, 1894–1896,

By W. E. SPERRA.

The following observed minima of this star are included between 1894 November 19 and 1896 January 12. The times are Greenwich mean times, and are not corrected for the "Equation of Light." The method of reduction has been by the usual single curve, by Dr. CHANDLER's mean curves (*A.J.* Vol. IX, p. 52), and by equal lights read from single curve. The weights given to the results obtained from the mean light-curve reductions indicate the number of observations from which they were individually derived.

1894 November 19; fourteen observations, from $14^h\ 58^m$ to $21^h\ 23^m$.

Time of minimum by single curve, $18^h\ 42^m$.
" " mean curve, 18 41.9, wt. 7.
" " equal light, 18 46.4.

M	Before h m	After h m	Mean h m
8.2	16 50	20 47	18 48.5
8.4	17 4	20 29	18 46.5
8.6	17 15	20 18	18 46.5
8.8	17 26	20 6	18 46.0
9.0	17 37	19 52	18 44.5
Mean			18 46.4

1894 December 4; twenty observations, from $13^h\ 37^m$ to $20^h\ 52^m$.

Time of minimum by single curve, $17^h\ 26^m$.
" " mean curve, 17 41.3, wt. 10.
" " equal light, 17 38.4.

M	Before h m	After h m	Mean h m
8.2	15 48	19 42	17 45.0
8.4	16 2	19 25	17 44.5
8.6	16 8	19 9	17 38.5
8.8	16 14	18 53	17 33.5
9.0	16 22	18 39	17 30.5
Mean			17 38.4

1894 December 19; seventeen observations, from $13^h\ 18^m$ to $19^h\ 37^m$.

Time of minimum by single curve, $16^h\ 56^m$.
" " mean curve, 16 38.7, wt. 11.
" " equal light, 16 44.2.

M	Before h m	After h m	Mean h m
8.2	14 39	18 35	16 37.0
8.4	14 59	18 21	16 40.0
8.6	15 14	18 14	16 44.0
8.8	15 26	18 10	16 48.0
9.0	15 39	18 5	16 52.0
Mean			16 44.2

1895 February 2; seventeen observations, from $11^{h}\,51^{m}$ to $15^{h}\,12^{m}$.

Time of minimum by single curve, $13^{h}\,46^{m}$.
" " mean curve, 13 35.3, wt. 7.
" " equal light, 13 46.7

	Before	After	Mean
M	h m	h m	h m
8.6	11 56	15 19	13 37.5
8.8	12 9	15 10	13 39.5
9.0	12 20	15 4	13 47.0
9.2	12 32	14 54	13 43.0
Mean			13 46.7

Lowest observed light, $9^{m}.15$.

1895 May 20; fifteen observations, from $14^{h}\,51^{m}$ to $20^{h}\,17^{m}$.

Time of minimum by single curve, $18^{h}\,10^{m}$.
" " mean curve, 18 21.5, wt. 9.
" " equal light, 18 18.5.

	Before	After	Mean
M	h m	h m	h m
8.4	16 28	20 15	18 21.5
8.6	16 39	20 3	18 21.0
8.8	16 45	19 49	18 17.0
9.0	16 52	19 37	18 14.5
Mean			18 18.5

Lowest observed light, $9^{m}.37$.

1896 January 12; thirteen observations, from $11^{h}\,36^{m}$ to $15^{h}\,11^{m}$.

Time of minimum by single curve, $14^{h}\,9^{m}$.
" " mean curve, 14 13.5, wt. 6.
" " equal light, 14 9.8.

	Before	After	Mean
M	h m	h m	h m
8.8	12 38	15 43	14 10.5
9.0	12 44	15 38	14 11.0
9.2	12 50	15 26	14 8.0
Mean			14 9.8

Lowest observed light, $9^{m}.60$.

Randolph, Ohio, 1897 *Feb.* 8.

MAXIMA AND MINIMA OF LONG-PERIOD VARIABLES,

By J. A. PARKHURST.

294. *W Cassiopeae.*

My observations of this star began 1894 Dec. 5, and have been continuous till the present time. When first seen it was about $11^{M}.5$, and after a slight fall rose to the maximum on 1895 July 11, making the interval $M-m$ not less than 208 days. The last observed maximum was 1896 Aug. 28, with the interval $M-m$ 222 days. The date of maximum is 100 days late of the ephemeris, but my light-curve, though flat, is not consistent with a maximum earlier than Aug. 9, or later than Sept. 25. The maximum magnitude was 8.4, and the observations number 74 in all.

659. *χ Cassiopeae.*

Since the last minimum I have 24 observations, yielding a faint maximum, $10^{M}.2$, 1896 Oct. 8. The rise was gradual, and the fall slightly faster, to $11^{M}.0$ on Dec. 12.

6207. *Z Ophiuchi.*

This season's observations began 1896 May 28, when the star was $9^{M}.0$. It fell slowly to a minimum, $12^{M}.3$ on Sept. 27, then rose to $11^{M}.2$ at the last observation Nov. 26. The curve at this minimum was quite flat, which, combined with the low position of the star, renders the determination uncertain by 10 or 15 days.

6449. *T Draconis.*

This star fell quite rapidly during 1896 May to August, then more slowly to a minimum, $10^{M}.9$, on Oct. 4. The rise following was a little slower than in 1895, with the same indications of a stand-still at $10^{M}.2$ during the third month after minimum. A secondary minimum is suspected here, but the evidence is not yet conclusive. The interval between my two minima is 428 days.

6549. *W Lyrae.*

My observations began 1896 Oct. 3, when the star was becoming fainter. It fell from $8^{M}.3$ to less than 12^{M} at the last comparison, Dec. 24. The fall during the last month was only 1^{M}, as compared with $2^{M}.5$ during the preceding month, the form of the curve suggesting a minimum of about 13^{M} early in 1897. There is a 12^{M} star $10^{s}.4$ prec., $1'.6$ south, and a 12^{M}, $3^{s}.5$ prec., $0'.7$ south.

6871. *V Lyrae.*

I have 11 observations of this star between 1896 Sept. 22 and 1897 Jan. 9. I found a rise from $9^{M}.8$ to a maximum, $9^{M}.4$, on 1896 Oct. 18 (the second of Mr. H. M. PARKHURST's maxima), followed by a rapid fall to less than $11^{M}.3$ at the last comparison. The rate of fall was retarded during the last month.

7085. *RT Cygni.*

Since the maximum in 1896 July, I have 22 observations, giving a minimum, $11^{M}.7$ on 1896 Oct. 26. The rate of rise and fall are about equal.

7458. *V Delphini.*

This star was not seen, therefore, below 12^{M}, 1896 Aug. 10, 26, and Sept. 23. It was seen at $12^{M}.4$ Oct. 5, and had risen suddenly to $9^{M}.8$ on Oct. 24. It was followed till 1897 Jan. 23, the curve giving a maximum, $9^{M}.0$, on 1896 Nov. 24. The fall was rapid, reaching $11^{M}.3$ at the last observation. There is a $12^{M}.2$ star $8^{s}.2$ prec., $0'.7$ north, and three 11^{M} 12^{M} stars, forming a slightly curved line 2′ long. 14^{s} following.

7192. *RZ Cygni.*

This star was first identified 1895 Nov. 19, at $12^{M}.0$. It remained at this brightness till 1896 Mar. 1. Then followed a break in the series till May 28, when it was seen unchanged. The next comparison was made Aug. 3, when the star had risen to $10^{M}.1$. It was about stationary during August, falling slowly to $12^{M}.0$ by November, and reaching $12^{M}.7$, 1896 Jan. 6, when last seen. The maximum probably occurred between July 15 and Aug. 15, at about $10^{M}.0$. My observations number 31. The variable is $9^{s}.0$ following 16°3078 (not $18^{s}.7$, as given by Espin in *A.N.* 3198), and $0'.1$ south.

8324. *V Cassiopeae.*

My regular watch on this star has been continued, 17 observations between 1896 Aug. 3 and Dec. 12 yielding a minimum, $12^{M}.4$, on Oct. 3. The brightness on the first named date was $10^{M}.0$, and on the last, $9^{M}.7$.

Marengo, Ill., 1896 *Jan.* 30.

NOTE ON THE VARIABLE 7792 *SS CYGNI*,

BY PAUL S. YENDELL.

I began my observations of this star on 1896 December 31, and observed it as often as possible until 1897 February 1.

The nine observations secured, though not definitely indicating a date of maximum, fully confirm the fact of the star's variation.

The observations, reduced by J. A. Parkhurst's magnitude-scale to facilitate comparison, are as follows:

		M	
1896 Dec. 31.3	Local M.T.	11.0	
1897 Jan. 2.3		10.9	
6.3		10.9	
9.3		10.9	
23.3		8.7	
25.3		8.6	
30.3		10.8:	star very low
31.3		10.5::	" " "
Feb. 1.3		10.2::	" " "

Taken in connection with Mr. Parkhurst's, the above observations afford strong indication that the star is a second example of the type of *U Geminorum*. It is much to be regretted that the gap from my observation of Jan. 9 to Parkhurst's of Jan. 19 includes the whole increase of the star's light, and probably a part of its decrease, the greatest light observed being nearly a magnitude and a half less than that given in the original announcement. The duration of the light-changes is confined by these observations to 21 days, or, if we accept the announced period of 40 days, the observation of Mr. Parkhurst on 1896 Dec. 20 reduces it to one day less. It seems likely, however, that further observation may materially reduce this value, and that the increase took place in much less time than the ten-day interval in the January observations. Neither on this point, nor on the data from which the 40-day period was inferred, does the original announcement from Harvard Observatory afford any information, but in view of the great irregularity of the period of *U Geminorum*, it is possible that *SS Cygni* may also prove to a considerable degree irregular. Consequently it is very desirable that it should be followed up by those observers who make a practice of morning work, so that no doubt may arise as to the actual number of epochs elapsed.

Dorchester, Mass., 1897 *Feb.* 11.

SEARCH FOR COMET OR COMETS REPORTED BY SWIFT, SEPT. 20,

BY W. J. HUSSEY.

On Sept. 21, 1896, a telegram from Mr. Swift was received here as follows: "Last night at sunset object as bright as *Venus*, one degree east of sun."

That afternoon, with a Herschel-prism applied to the 12-inch telescope, I examined the region immediately about the sun, and then with a low-power eye-piece for several degrees on every side of the sun, without finding the object. As the sun set I again searched north, south and east of it, and the next morning as it arose, north, south and west of it, without success.

For several evenings and mornings Mr. Perrine searched with the comet-seeker the region for many degrees about the sun.

Mt. Hamilton, Cal., 1897 *Feb.* 12.

CANALS OF *MARS*.

Mr. Percival Lowell telegraphs from Mexico, March 3: "Martian canals doubling *passim*."

OBSERVATIONS OF SMALL PLANETS,

MADE AT THE U.S. NAVAL OBSERVATORY WITH THE 12-INCH EQUATORIAL,

BY EDGAR FRISBY.

[Communicated by Prof. WM. HARKNESS, U.S.N., Astronomical Director.]

1896 Washington M.T.	*	No. Comp.	Planet − * Δα	Planet − * Δδ	Planet's Apparent α	Planet's Apparent δ	log p for α	log p for δ
			(51) *Nemausa.*					
Oct. 7 11h 4m 1s.8	1	20 , 4	+1m 31s.96	−10′ 8″.2	2h 13m 31s.21	+ 4° 43′ 0″.1	n9.3617	0.7003
9 11 26 21.3	2	20 , 4	+2 21.35	+ 0 55.0	2 11 58.67	+ 4 24 26.7	n9.2360	0.7005
31 11 33 4.4	3	20 , 4	+1 2.63	+ 6 2.1	1 52 53.39	+ 1 16 11.5	8.6860	0.7301
			(80) *Sappho.*					
Oct. 31 11 7 7.5	4	20 , 4	+2 1.48	− 5 6.2	1 35 45.01	+11 50 4.0	8.4927	0.6164
			(387) 1894 *AZ.*					
Oct. 31 12 12 29.9	5	20 , 4	−4 54.03	− 9 10.4	3 37 54.62	− 7 29 34.4	n8.9175	0.8237
Nov. 6 11 25 11.5	6	19 , 4	−0 17.21	− 6 44.4	3 32 41.72	− 7 50 9.4	n9.0759	0.8050
			(8) *Flora.*					
Nov. 27 12 17 42.1	7	20 , 4	−1 9.40	+ 8 5.9	4 45 34.61	+14 13 0.9	7.7243	0.5622
Dec. 3 11 33 55.9	8	14 , 3	−0 2.73	− 1 59.7	4 38 53.53	+14 24 16.9	n8.3556	0.5616
4 10 18 16.8	8	20 , 4	−1 5.94	+ 0 7.6	4 37 50.31	+14 26 24.1	n9.2199	0.5729

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	2h 11m 52s.09	+4s.19	+ 4° 52′ 40″.6	+27″.7	Boss, Albany A.G. Catal. 645
2	2 9 33.10	+4.22	+ 4 23 3.9	+27.8	Boss, Albany A.G. Catal. 630
3	1 51 46.34	+4.42	+ 1 10 11.4	+28.0	Boss, Albany A.G. Catal. 552
4	1 33 39.13	+4.43	+11 54 41.0	+29.2	Schjellerup 492
5	3 42 44.31	+4.31	− 7 20 48.2	+24.2	Radcliffe (1890) 888
6	3 33 21.54	+4.39	− 7 43 49.0	+24.0	Radcliffe (1890) 848
7	4 46 38.89	+5.12	+14 4 38.8	+16.2	Radcliffe (1890) 1150
8	4 38 51.06	+5.20 +5.22	+14 26 0.0	+16.6 +16.5	Grant 1149

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Some copies of earlier volumes, excepting the first, are still remaining, and all, excepting the first three, may be obtained at the same price. A limited number of copies of the Atlas of the *Uranometria Argentina* are for sale at $6.00.

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THE SECULAR PERTURBATIONS OF *MERCURY*,

By ERIC DOOLITTLE.

The elements which have been used in the following computation were taken in each case from Dr. G. W. HILL's *"New Theory of Jupiter and Saturn;"* those of the four inner planets are found on page 192, of *Jupiter* and *Saturn* on page 558, of *Uranus* on page 109, and of *Neptune* on page 161. The mass of *Uranus* has, however, been taken as $\frac{1}{22,800}$, as suggested by Dr. HILL (*Astronomical Journal*, no. 316).

The method employed is the modification of GAUSS's method published by Dr. HILL in the *Astronomical Papers Prepared for the Use of the American Ephemeris*, Vol. I, 1882. The work in each case has been carried through twice from the beginning at different times, and verification-formulas and different forms of the equations have been used in the duplication where it was possible.

The perturbations arising from the action of *Venus* were published by Dr. HILL in his memoir *"On GAUSS's Method of Computing Secular Perturbations,"* and the results have been verified by Dr. LOUIS ARNDT (*Recherches sur le calcul des Forces Perturbatrices dans la Théorie des Perturbations Séculaires. Bulletin de la Société des Sciences Naturelles de Neuchatel.* Tome XXIV, 1896). The results are hence adopted in the following without further verification, except that the mass $\frac{1}{425,000}$ has been adopted for *Venus* instead of LEVERRIER's value, $\frac{1}{401,847}$, which was employed by Dr. HILL.

The perturbations arising from the action of the *Earth*, *Mars*, *Jupiter* and *Saturn*, respectively, have been published in the *Astronomical Journal*, nos. 376, 381, 386 and 392. Those arising from *Uranus* and *Neptune* were computed from the following elements:

Mercury

$$\begin{aligned} \pi &= 75^\circ\ 7'\ 13''.62 \\ i &= 7\ \ 0\ \ 7.71 \\ \Omega &= 46\ 33\ \ 8.63 \\ e &= 0.20560476 \\ \log a &= 9.5878217 \\ m &= \tfrac{1}{5\,000\,000} \end{aligned}$$

Uranus

$$\begin{aligned} \pi' &= 168^\circ\ 15'\ \ 6''.7 \\ i' &= 0\ 46\ 20.54 \\ \Omega' &= 73\ 14\ \ 8.0 \\ e' &= 0.0469236 \\ \log a' &= 1.2831044 \\ m' &= \tfrac{1}{22,800} \end{aligned}$$

Neptune

$$\begin{aligned} \pi' &= 43^\circ\ 17'\ 30''.3 & e' &= 0.0084962 \\ i' &= 1\ 47\ \ 1.68 & \log a' &= 1.4781414 \\ \Omega' &= 130\ \ 7\ 31.83 & m' &= \tfrac{1}{19,700} \end{aligned}$$

Epoch 1850.0 Greenwich Mean Time.

The resulting values of the preliminary constants were, in the two cases,

$$\begin{aligned} I &= 6^\circ\ 19'\ 17''.40 & I &= 7^\circ\ \ 1'\ 42''.65 \\ \Pi &= 211\ 43\ 10.39 & \Pi &= 223\ 12\ 39.15 \\ \Pi' &= 304\ 49\ 47.06 & \Pi' &= 191\ 16\ 25.42 \\ K &= 266\ 43\ 32.95 & K &= 324\ 34\ \ 3.91 \\ K' &= 267\ \ 3\ 12.48 & K' &= 324\ 24\ \ 7.31 \\ \log k &= 9.9982188 & \log k &= 9.9968502 \\ \log k' &= 9.9991396 & \log k' &= 9.9998757 \\ \log c &= 9.9089914 & \log c &= 8.8147322 \\ c &= 0.81094500 & c &= 0.065272791 \end{aligned}$$

The orbit of *Mercury* was in each case divided into eight parts with reference to the eccentric anomaly, and the sums of the functions corresponding to the odd and even points of division, respectively, were in substantial agreement. The residuals from the equation

$$\sin q \,.\, \tfrac{1}{2} A_1^{(s)} + \cos q \,.\, B_o^{(c)} = 0$$

were $+0.000\,000\,000\,049$ and $+0.000\,000\,000\,098$ respectively. The resulting values of the differential coefficients were as follows:

Action of *Uranus*.

$$\begin{aligned} & & & \text{log coeff.} \\ \left[\frac{de}{dt}\right]_{00} &= +\ 0''.219\,756\,50\ m' & & p9.341\,9417 \\ \left[\frac{d\chi}{dt}\right]_{00} &= +32.406\,731\ \ m' & & p1.510\,6352 \\ \left[\frac{di}{dt}\right]_{00} &= -\ 0.557\,450\,51\ m' & & n9.746\,2063 \\ \left[\frac{d\Omega}{dt}\right]_{00} &= -30.777\,028\ \ m' & & n1.488\,2267 \\ \left[\frac{d\pi}{dt}\right]_{00} &= +32.177\,180\ \ m' & & p1.507\,5480 \\ \left[\frac{dL}{dt}\right]_{0} &= -45.859\,693\ \ m' & & n1.661\,4312 \end{aligned}$$

Action of *Neptune.*

			log coeff.
$\left[\frac{de}{dt}\right]_{00}$	$= +0''.065401848$	m'	$p8.8155900$
$\left[\frac{d\chi}{dt}\right]_{00}$	$= +8.2544736$	m'	$p0.9166894$
$\left[\frac{di}{dt}\right]_{00}$	$= -0.39452600$	m'	$n9.5960756$
$\left[\frac{d\Omega}{dt}\right]_{00}$	$= -8.7298700$	m'	$n0.9410078$
$\left[\frac{d\pi}{dt}\right]_{00}$	$= +8.1893623$	m'	$p0.9132501$
$\left[\frac{dL}{dt}\right]_{00}$	$= -11.826130$	m'	$n1.0728427$

If we adopt the above values of m', we obtain the following results:

	Uranus	*Neptune*
$\left[\frac{de}{dt}\right]_{00} =$	$+0''.00000963841$	$+0''.00000331989$
$\left[\frac{d\chi}{dt}\right]_{00} =$	$+0.0014213479$	$+0.00041900885$
$\left[\frac{di}{dt}\right]_{00} =$	-0.00002444958	-0.00002002670
$\left[\frac{d\Omega}{dt}\right]_{00} =$	-0.0013498699	-0.00044314061
$\left[\frac{d\pi}{dt}\right]_{00} =$	$+0.0014112801$	$+0.00041570371$
$\left[\frac{dL}{dt}\right]_{00} =$	-0.0020113907	-0.00060031125

The entire variations of the elements may now be expressed by the following equations:

$$\left[\frac{de}{dt}\right]_{00} = +0''.0413949 \; +0''.0266383\,\nu' \; +0''.0116259\,\nu'' \; -0''.000607428\,\nu''' \; +0''.00319113\,\nu^{\mathrm{iv}} \; +0''.0005310952\,\nu^{\mathrm{v}} \; +0''.00000963844\,\nu^{\mathrm{vi}} \; +0''.00000331989\,\nu^{\mathrm{vii}}$$

$$\left[\frac{d\chi}{dt}\right]_{00} = +5''.1827279 \; +2''.6661693\,\nu' \; +0''.9263870\,\nu'' \; -0''.024863343\,\nu''' \; +1''.540072\,\nu^{\mathrm{iv}} \; +0''.073122627\,\nu^{\mathrm{v}} \; +0''.0014213479\,\nu^{\mathrm{vi}} \; +0''.00041900885\,\nu^{\mathrm{vii}}$$

$$\left[\frac{di}{dt}\right]_{00} = -0''.2100818 \; -0''.14223348\,\nu' \; -0''.0142236\,\nu'' \; -0''.000301915\,\nu''' \; -0''.0490656\,\nu^{\mathrm{iv}} \; -0''.004212776\,\nu^{\mathrm{v}} \; -0''.000024449581\,\nu^{\mathrm{vi}} \; -0''.00002002670\,\nu^{\mathrm{vii}}$$

$$\left[\frac{d\Omega}{dt}\right]_{00} = -1''.4525431 \; -1''.8649519\,\nu' \; -1''.0167843\,\nu'' \; -0''.019261347\,\nu''' \; -1''.479953\,\nu^{\mathrm{iv}} \; -0''.069796619\,\nu^{\mathrm{v}} \; -0''.0013498699\,\nu^{\mathrm{vi}} \; -0''.00044314061\,\nu^{\mathrm{vii}}$$

$$\left[\frac{d\pi}{dt}\right]_{00} = +5''.1992464 \; +2''.6522595\,\nu' \; +0''.9188043\,\nu'' \; +0''.024719659\,\nu''' \; +1''.529034\,\nu^{\mathrm{iv}} \; +0''.072602050\,\nu^{\mathrm{v}} \; +0''.0014112801\,\nu^{\mathrm{vi}} \; +0''.00041570371\,\nu^{\mathrm{vii}}$$

$$\left[\frac{dL}{dt}\right]_{00} = -6''.6793362 \; -3''.1215264\,\nu' \; -1''.2090529\,\nu'' \; -0''.032933242\,\nu''' \; -2''.206638\,\nu^{\mathrm{iv}} \; -0''.10657405\,\nu^{\mathrm{v}} \; -0''.0020113907\,\nu^{\mathrm{vi}} \; -0''.00060031125\,\nu^{\mathrm{vii}}$$

In the above equations, the quantities $\nu', \nu'', \nu''' \ldots$ are corrections to the masses adopted above for *Venus*, the *Earth*, *Mars*, etc., respectively, and which are connected with the true masses, $m', m'', m''' \ldots$ by the equations,

$$m' = m_0'(1+\nu'); \quad m'' = m_0''(1+\nu''); \quad m''' = m_0'''(1+\nu'''). \text{ etc.}$$

The coefficients have been written to as many decimal places as the numerical work seems to justify, and may be considered as an indication of the accuracy of the computation merely.

If we give to $\nu', \nu'', \nu''' \ldots$ the values necessary to correct the assumed masses to those adopted by LeVerrier (*Annales de l'Observatoire de Paris*, Vol. V, p. 19), the resulting values of the differential coefficients compare with those of LeVerrier as in the following table.

The final column gives the results of Newcomb (*Papers Prepared for the Use of the American Ephemeris*, Vol. V, Part IV. *The Secular Variations of the Four Inner Planets*).

Flower Observatory, 1897 Feb. 26.

	Method of LeVerrier	Method of Gauss	Results of Newcomb
$\left[\frac{de}{dt}\right]_{00}$	$+0''.04188$	$+0''.01185$	$+0''.01139$
$\left[\frac{d\pi}{dt}\right]_{00}$	$+5.2716$	$+5.2654$	$+5.3180$
$\left[\frac{di}{dt}\right]_{00}$	-0.21702	-0.21689	-0.21503
$\left[\frac{d\Omega}{dt}\right]_{00}$	-4.4464	-4.4654	-4.6527
$\left[\frac{dL}{dt}\right]_{00}$	-6.7766*	-6.7460	

It is thus evident that the want of agreement between LeVerrier's results and those expressed by the equations written above, arises from differences in the assumed masses.

---

* This value does not include the action of *Uranus* and *Neptune*.

VARIATIONS IN THE DECLINATION-SYSTEM OF THE *BERLINER JAHRBUCH*,

By R. H. TUCKER.

The observed zenith-distances of standard stars may serve not only to furnish a value of the latitude by the Meridian-Circle, but also as a comparative test of the declinations of the list.

Two groups will be considered here; one containing stars within about 20° of the pole, and which can be observed at both culminations, and the other a selected list of equatorial stars, between +15° and −10°. Since these stars were observed as fundamentals to furnish places for another list, no special effort has been made to secure uniformity in the number or distribution of the observations, but these are sufficient to give, in general, confidence in the results. Of the first group there are 32 stars observed at both culminations, and 13 at one culmination only.

Leaving aside, for the present, the effect of latitude-variation, those observed at both culminations furnish a value of φ which is independent of the error of declination.

While the figures are mainly of local interest, they will be used here as the medium of comparison, and are accordingly quoted in full.

The value of φ from the direct mean of the 32 stars is $37^\circ\, 20'\, 25''.52$, and the p.e. for one star is $\pm 0''.10$. This probable error is due to observation, in which are included the errors of graduation, and the differential effect of the refraction and flexure constants.

The mean φ at U.C. is $25''.49$,
and at L.C. $25''.55$.

If all the stars observed be included,

the mean φ at U.C. is $25''.49$ for 36 stars,
and at L.C. $25''.49$ for 41 stars.

The p.e. of φ from a single star, are respectively, $\pm 0''.23$ U.C., and $\pm 0''.28$ L.C.

The probable error of observation can be determined by comparison of observations made circle East and West. There results for the mean of the two positions,

for U.C. $\pm 0''.14$ from 29 stars,
and L.C. $\pm 0''.20$ from 28 stars.

From the p.e. of an observed φ, and the p.e. due to observation, there is obtained $\pm 0''.19$, for the probable error of a single B.J. declination.

The latitude determined from circumpolar stars is affected by certain classes of systematic errors, among them such as depend upon flexure, refraction, and the error of bisection, which may be of the nature of a personal equation. All these errors operate in the same sense upon the zenith-distances measured at the two culminations, introducing a correction to the observed value of φ, which may be nearly a constant, for the mean angle measured.

Turning now to determinations made south of the zenith, the mean φ from the equatorial list of 86 stars observed is $25''.65$; with p.e. for one star, $\pm 0''.25$. The largest residuals are $+0''.81$ and $-0''.89$.

Comparison of determinations circle East and West, for 72 stars thus observed, give the p.e. of observation for the mean of both positions $\pm 0''.13$.

The p.e. of an observed φ for this list of 72 stars is $\pm 0''.24$; whence there results the p.e. of a B.J. declination, $\pm 0''.20$.

This value of φ is affected by the same classes of systematic error as the value from the polar stars, acting in the contrary sense; and also by the mean error of the declinations of the list.

The difference, $0''.13$, between φ from the circumpolar stars observed at both culminations, and φ from the equatorial list, includes the mean error of this last, and double the effect of the systematic errors of observation. Since it is almost precisely satisfied by the bisection-correction, $0''.06$, which has been independently determined, the remaining sources of error must be very small, unless they balance in their effect.

With the 72 equatorial stars as a basis, the systematic deviations can be studied. The results can best be presented in the form of Table I, for which some slight explanation only will be necessary. The mean φ of three successive stars is first taken; the residuals of these groups will then represent the hourly deviation as well as the material will permit.

The residual is to be interpreted as the observed *error* of the B.J. declination. Groups of six successive stars give the deviation for two hours, and the combination is thus carried up to six hours. The average of the residuals is given at the foot.

For the hourly groups it may be added that the p.e. of a group is $\pm 0''.14$, which would also result from the p.e. of one star, on the assumption that these groups present accidental deviations only.

The circumpolar determinations are treated in a similar manner in Table II. The residuals are obtained directly from the U.C. observations, and from the L.C. with reversed sign. All 45 stars have been included, an average of nearly two per hour, or of four in the two-hour groups. The residuals do not exactly balance in sign, since stars at one culmination have been given the same weight as those at both.

The p.e. of φ for a single star, observed at both culminations, is $\pm 0''.24$, the largest residuals being $+0''.57$ and $-0''.68$.

The p.e. of observation, obtained from the difference between the two culminations, is $\pm 0''.10$ for the mean;

whence the p.e. of a B.J. declination would be ±0″.22, somewhat larger than the result from the single culminations.

Evidence of systematic deviations is plain in both series of observations, and appears as an annual term when the results are plotted by nights. That the effect is not directly to be traced to the season, is evident in the case of circumpolar stars, which give results in good agreement at epochs approximately six months apart for the two culminations.

A value of the latitude deduced from simultaneous observation of the two lists of stars, while it would present systematic deviations corresponding to the mean of both, would still be nearly free from the effect of the systematic errors of observation, referred to above.

The mean deviations observed for the two lists are given in Table III.

TABLES I–III. DEVIATION OF OBSERVED q_0

I. EQUATORIAL STARS								II. CIRCUMPOLAR STARS						III. MEAN OF EQUAT. AND CIRC. STARS					
Hourly, 3 ✱		2 hours		4 hours		6 hours		2 hours		4 hours		6 hours		2 hours		4 hours		6 hours	
α	v	α	v	α	v	α	v	α	v	α	v	α	v	α	v	α	v	α	v
h	″	h	″	h	″	h	″	h	″	h	″	h	″	h	″	h	″	h	″
0.5	+0.25		–	–	–	–	–	1.1	+0.17	–	–	–	–	1	+0.12	–	–	–	–
1.8	– .09	1.1	+0.08	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2.9	– .01	–		–	–	–	–	2.6	+ .31	1.8	+0.21	–	–	3	+ .06	2	+0.09	–	–
3.8	– .33	3.4	– .19	2.2	– 0.05		–	–	–	–	–	–	–	–	–	–	–	–	–
4.8	+ .23		–	–	–		–	1.4	– .01	–	–	2.7	+0.16	5	+ .11	–	–	3	+0.11
6.0	+ .33	5.4	+ .28	–	–	3.3	+0.06	–	–	–	–	–	–	–	–	–	–	–	–
6.8	+ .17	–	–	–	–	–	–	6.2	– .28	5.3	– .14	–	–	7	+ .01	6	+ .07	–	–
7.7	+ .14	7.2	+ .31	6.3	+ .29	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8.9	+ .28	–	–	–	–	–	–	8.4	+ .31	–	–	–	–	9	+ .30	–	–	–	–
9.8	+ .31	9.2	+ .29	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
10.9	– .10	–	–	–	–	–	–	10.9	+ .28	9.6	+ .29	8.5	+0.10	11	+ .09	10	+ .19	9	+ .13
11.7	– .10	11.3	– .10	10.3	+ .10	9.3	+0.17	–	–	–	–	–	–	–	–	–	–	–	–
12.6	– .20	–	–	–	–	–	–	13.8	+ .16	–	–	–	–	13	– .01	–	–	–	–
13.5	– .17	13.0	– .19	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
14.9	+ .07	–	–	–	–		–	15.9	+ .01	14.8	+ .08	–	–	15	– .03	14	– .02	–	–
16.0	– .21	15.5	– .07	14.2	– .13		–	–	–	–	–	–	–	–	–	–	–	–	–
17.2	– .12	–	–	–		–	–	17.6	– .17	–	–	15.8	0.00	17	– .12	–	–	15	– 0.5
17.8	– .05	17.5	– .08	–	–	15.3	–0.11	–	–	–	–	–	–	–	–	–	–	–	–
19.2	– .09	–	–	–	–	–	–	19.1	– .13	18.3	– .15	–	–	19	– .12	18	– .12		–
19.9	– .13	19.5	– .11	18.5	– .10		–	–	–	–	–	–	–	–	–	–	–	–	–
20.8	– .11	–	–	–	–	–	–	20.7	– .23	–	–	–	–	21	– .16	–	–	–	–
21.9	– .06	21.1	– .09	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
22.7	+ .08	–	–	–	–	–	–	22.6	–0.23	21.7	–0.23	20.8	–0.20	23	–0.17	22	–0.16	21	–0.15
23.6	–0.30	23.2	–0.11	22.3	–0.10	21.3	–0.10	–	–	–	–			–	–	–	–	–	–
Av.	±0.18		±0.16		±0.13		±0.11	Av.	±0.19		±0.19		±0.12	Av.	±0.11		±0.11		±0.11

I. Equatorial Stars:
0ʰ–11ʰ = +0″.11
12–23 = –0.11
4ʰ–11ʰ = +0″.19
12–19 = –0.11
20–3 = –0.08

II. Circumpolar Stars:
0ʰ–11ʰ = +0″.13
12–23 = –0.10
4ʰ–11ʰ = +0″.07
12–19 = –0.03
20–3 = +0.01

III. Mean of Equat. and Circ. Stars:
0ʰ–11ʰ = +0″.12
12–23 = –0.10
4ʰ–11ʰ = +0″.13
12–19 = –0.07
20–3 = –0.01

The effect of latitude-variation can best be studied by arranging the determinations in a consecutive series of nights.

Before applying any correction, the direct means of 161 nights used are: q at U.C. 25″.50, at L.C. 25″.43, the mean being 25″.47, from the circumpolar stars. This differs slightly from the direct mean by stars, since, in the last, weights depending upon the number of observations were not assigned.

The value of q, from the series of nights, for the equatorial stars is 25″.65, the same as given by the direct mean by stars.

The mean q given by the two lists of stars, circumpolar and equatorial, is 25″.56; and the mean of the two sets observed each night will be adopted, as the best value of q afforded by the material. In general there are 8 equatorial stars and 6 circumpolars per night.

The computed variation from CHANDLER's elements is small throughout the greater part of the series, which extends from September 1893 to June 1896. The average correction is but ±0″.05 per night, and only ±0″.02 during the first half. It did not amount to 0″.1 until July 1895, and the maximum correction is +0″.20 in February 1896. The mean $q - q_0$ is –0″.012; and the q_0 corresponding to this series of observations is accordingly 37° 20′ 25″.57.

The divergence of the annual term and the 14-month term will produce larger variations during the period ensuing. Observations with the Meridian-Circle have been continued without break since the close of the series which has been under consideration; and for this year about one hundred stars from Boss will be used as fundamental in declination.

Table IV.

Deviation of Observed φ_0			
		Means	
α	v	α	v
h	″	h	″
0.5	−0.05	–	
0.8	− .12	0.6	−0.08
1.5	− .21	1.5	− .21
2.0	− .11	2.0	− .11
3.6	− .06	3.6	− .06
4.3	− .07	–	–
4.8	+ .14	4.5	+ .03
5.0	− .20	–	–
5.6	− .08	5.3	− .14
6.2	+ .29	–	–
6.8	+ .20	6.5	+ .24
8.0	+ .16	–	–
8.2	+ .07		–
8.3	+ .15	–	–
8.8	+ .08	8.3	+ .12
9.0	+ .10	9.0	+ .10
11.0	+ .20	–	–
11.6	− .01	–	–
11.8	− .05	–	–
11.9	− .05	11.6	+ .02
12.6	− .33	12.6	− .33
13.6	− .18	13.6	− .18
14.1	− .07	14.1	− .07
15.2	− .01	15.2	− .01
16.0	+ .11	–	–
16.2	+ .15	16.1	+ .13
17.2	+ .31	–	–
17.4	− .26	17.3	+ .03
18.1	.00	–	–
18.4	+ .10	–	–
18.5	+ .16	–	–
18.8	− .04	18.4	+ .05
20.4	− .08	–	–
20.8	− .20	–	–
20.9	+ .18	20.7	− .03
21.4	+ .13	21.4	+ .13
22.2	− .22	–	–
22.5	.00	–	–
22.9	− .24	22.5	− .15
23.1	+0.25	23.1	+0.25
	Average		±0.13

Adjustment Observed φ_0				
Hourly		2 hours	4 hours	6 hours
α	v	v	v	v
h	″	″	″	″
0	−0.05	–	–	–
–	–	–	–	–
1	− .04	−0.05	–	–
	–	–	–	–
2	− .09	–	–	–
–	–	–	–	–
3	− .10	− .09	−0.07	–
–	–	–	–	–
4	− .01	–	–	–
–	–	–	–	–
5	+ .04	+ .01	–	−0.04
–	–	–	–	–
6	+ .07	–	–	–
–	–	–	–	–
7	+ .09	+ .08	+ .05	–
–	–	–	–	–
8	+ .13	–	–	–
–	–	–	–	–
9	+ .07	+ .10	–	–
–	–	–	–	–
10	− .02	–	–	–
–	–	–	–	–
11	− .07	− .04	+ .03	+ .04
–	–	–	–	–
12	− .11	–	–	–
–	–	–	–	–
13	− .13	− .12	–	–
–	–	–	–	–
14	− .09	–	–	–
–	–	–	–	–
15	− .02	− .05	− .09	–
–	–	–	–	–
16	+ .03	–	–	–
–	–	–	–	–
17	+ .05	+ 0.4	–	− .04
–	–	–	–	–
18	+ .03	–	–	–
–	–	–	–	–
19	+ .03	+ .03	+ .03	
–	–	–	–	–
20	.00	–	–	
–	–	–	–	–
21	+ .04	+ .02	–	–
–	–	–	–	–
22	+ .01	–	–	–
–	–	–	–	–
23	0.00	0.00	+0.01	+0.02
Average	±0.06	±0.05	±0.05	±0.04

0h – 11h = 0″.00 | 4h – 11h = +0″.04
12 – 23 = −0.01 | 12 – 19 = −0.03
20 – 3 = −0.03

The correction $q - q_0$ computed for each night has been applied. The p.e. of the observed q_0 for a single night, in the consecutive series, is ±0″.160, the largest residuals being +0″.70 and −0″.67.

The p.e. of observation for the stars is ±0″.08, whence the combined p.e. of the zenith-reading and the mean declination is ±0″.14.

Combining the observations of q_0 into groups of nights which contain the same stars, with but few exceptions, there are 40 groups with an average of four nights each. The p.e. of q_0 for a single night, deduced from these groups, is then ±0″.125, the largest residuals being +0″.47 and −0″.42. In these groups the effects of graduation-error, and of the declination-error are excluded, and the p.e. of observation of the stars becomes ±0″.07, leaving ±0″.10 for the p.e. of zenith-reading.

The probable error of a single nadir has been obtained from a comparison of 360 determinations, on 120 nights for which no rate was adopted, and is ±0″.18. The mean of three readings would have the p.e. ±0″.11, in good accord with the above. The p.e. of the mean declination, per night, would then be ±0″.10; much larger than would result from the combined accidental errors of declination alone, which may be adopted as ±0″.20 for a single star.

There is an apparent increase in q_0, exhibited in the following means of the series by years.

Epoch 1894.1	q_0 = 25″.52	Circle E
1895.1	25.56	W
1896.1	25.70	E

the third year having less than half as many determinations as the two preceding.

The groups afford a further test of the deviations, based upon q_0, and they have been arranged as follows, in the accompanying Table IV.

The residuals are taken from the above *yearly* means of q_0.

Each group extends over four hours, so that the residuals represent the mean deviation for a period including two hours each side; and an adjustment is then necessary to give terms that will correspond with the tables preceding. In making the adjustment the original groups are combined into a mean result, which includes the deviation of all the hours of right-ascension that have entered into the separate residuals.

This has naturally resulted in smoothing out the deviation into a set of residuals which probably represent the material as closely as possible, and are to be interpreted in the sense of observed systematic errors of the B.J. declinations.

Lick Observatory, University of California, 1897 *Jan.* 14.

NEW VARIABLE IN *VIRGO.*

$12^h\ 39^m\ 54^s$, +4° 56′.1 (1855).

By ARTHUR J. ROY.

In 1895 I found an 8^M star not recorded in the Bonn *Durchmusterung*. DM. +4°2651 precedes it 17^s, 0′.8 north, and DM. +4°2652 follows 25^s, 1′.1 north; both of which are there recorded as $9^M.5$. I occasionally observed it, but did not until recently become certain of its variability. Its position for 1895.0, from two observations by Prof. Boss with the Meridian-Circle, is $12^h\ 41^m\ 57^s.77$, +4° 43′ 8″.1. In the following estimates of the magnitude, it is only on Aug. 8, 1895, July 1, and Dec. 13, 1896, that I feel the uncertainty to be less than two-tenths of a magnitude. I have roughly estimated it to be 7 on Dr. Chandler's scale of redness.

	M		M
1895 May 7	8.0	1896 June 27	8.0
" 10	8.1	July 1	8.2
" 14	8.3	Dec. 13	9.0
Aug. 8	9.0	1897 Jan. 21	10.4
1896 Mar. 28	9.0	" 30	10.5
May 15	8.5	Mar. 1	12–11

PROBABLE NEW VARIABLE IN *PUPPIS*. (S.DM. —20°2007).

$7^h\ 26^m\ 20^s.9$, —20° 21′.4 (1855).

By ARTHUR C. PERRY.

While preparing to observe, for the first time, the variable star 2690 *X Puppis*, on March 1, I discovered that the star S.DM. −20°2007, there given as 10^M, was just about equal to −20°2009 and −20°2015, which are $8^M.6$ and $8^M.7$, respectively. The difference of about $1^M.5$ between its present brightness and the Bonn estimates, would seem to imply variability.

As I have no means of measuring the star's exact position, it is possible that a faint companion north following is −20°2007, although I think not, as it appears too faint to have been included in the S.DM.

Mr. Henry M. Parkhurst has kindly confirmed my estimate of the star's present brightness, and finds that the difference in α between the star in question and −20°2009 corresponds with the Catalogue $\Delta\alpha$ between −20°2007 and −20°2009.

Brooklyn, N.Y., 1897 *March* 9.

OBSERVATIONS OF THE FIFTH SATELLITE OF *JUPITER*,

By J. M. SCHAEBERLE.

As Barnard's satellite of *Jupiter* has not been observed since 1894 (see *A.J.* 367) the following series of measures will furnish desirable data for correcting the mean motion of the satellite should no further observations be secured during the present unfavorable season at Mt. Hamilton.

I had not previously attempted to observe this object, but quite readily found it with the aid of Marth's ephemeris, as the seeing was unusually good, and the planet near the meridian.

During the first part of the night the telescope was used for other purposes, so that before I was able to commence observing the satellite was already within half an hour of its greatest elongation. This accounts for the fact that the measures are not symmetrically situated with reference to the stationary point. Marth's ephemeris is still in good agreement with the observed place, the error in the time of elongation being less than four minutes.

Each time and corresponding distance, given below, is the mean of three separate observations made in quick succession.

Observations near Western Elongation, 1897 Feb. 27.

Pacific Stand. Time	Dist. from ♃ nearer limb	Dist. from ♃ center
h m s	″	″
11 10 21	31.77	54.46
51 6	32.41	55.10
11 59 6	33.21	55.90
12 7 23	33.46	56.15
15 18	33.60	56.29
21 11	33.41	56.10
30 58	32.09	54.78
12 35 46	31.66	54.35
12 40 58	30.96	53.65
14 56	30.72	53.41
50 31	29.25	51.94
12 55 33	28.49	51.18
13 2 30	27.08	49.77
8 23	25.52	48.21
15 11	23.63	46.32
13 21 58	21.47	44.16

I have used Barnard's equatorial semi-diameter of *Jupiter* for obtaining the values given in the last column.

Lick Observatory, University of California, 1897 *Mar.* 1.

NOTES ON PROPER MOTIONS OF STARS IN ZONE 50°–55° NORTH DECLINATION.

By J. G. PORTER.

In the course of my investigations of proper motions, I have had occasion to examine the stars in the above zone to which motion exceeding $0''.12$ is assigned in the introduction of Rogers's A.G. Catalogue. A few of the very large motions there indicated have been found to be fallacious, and since these may well mislead observers who make use of the catalogue, I think it advisable to call attention to them. Some other stars are added where the Cincinnati observations fail to corroborate the motion given. The star-positions are for 1900, and have been reduced to the A.G. system by Auwers's tables.

Rogers 2640.

	Epoch	α	δ	Obs.
		h m s	° ′ ″	
Fedorenko	1790.2	6 44 20.99	+54 9 45.0	1
Vienna	1859.6	21.79	36.2	1
Rogers	74.5	22.28	39.2	3
Cincinnati	96.7	22.16	37.6	3

The motion, $+0^s.015$, assigned by Rogers becomes very doubtful. More likely Fedorenko's α is 1^s too small.

Rogers 3181. The large motion assigned in α, $+0^s.106$, is due to erroneous precession. Instead of $4^s.4581$ read $4^s.5581$.

Rogers 3214.

	Epoch	α	δ	Obs.
		h m s	° ′ ″	
Berlin	1854.0	8 38 30.47	+54 16 44.5	3
Rogers	74.2	31.09	44.3	2
Cincinnati	94.2	31.02	42.0	3

Rogers's motion, $+0^s.024$, is not borne out by the Cincinnati observations. It is impossible to decide at present whether motion exists or not.

Rogers 3591. The precession given in the catalogue for this star is correct, yet the large proper motion assigned, $-0^s.095$, is evidently due to the use of a precession too great by one-tenth of a second in bringing up the previous observations. The motion is insensible.

Rogers 4454–5. No. 4455 should be corrected $-1'$ in declination. Both Struve and Argelander observed the following star, but these observations have been compared with the preceding one in Rogers's catalogue. Hence the erroneous motion $-0^s.040$.

Rogers 1545.

	Epoch	α	δ	Obs.
		h m s	° ′ ″	
Bonn	1862.4	14 27 20.85	+53 53 6.6	1
Pulkowa	62.5	20.92	5.4	1
Rogers	71.8	21.20	3.6	3
Cincinnati	95.7	21.01	6.0	4

The Cincinnati position fails to corroborate the motion given.

Rogers 4640–1. The two positions given belong to the same star, which is not double. Its large proper motion accounts for the difference in the two places which are separated in epoch by ten years.

Rogers 5181.

	Epoch	α	δ	Obs.
		h m s	° ′ ″	
Oe. Argelander	1841.4	17 7 51.14	+51 20 54.9	1
Rogers	73.6	51.57	53.8	3
Cincinnati	94.5	51.51	53.5	3

The Cincinnati position does not substantiate the motion.

Rogers 5451.

	Epoch	α	δ	Obs.
		h m s	° ′ ″	
Rümker	1817.0	18 2 44.45	+53 13 11.0	1
Rogers	75.7	14.40	6.5	2
Cincinnati	94.7	14.33	11.8	3.4

If this star has motion it would seem to be in the opposite direction from what Rogers gives. Perhaps Rümker's place is 10″ too great in declination.

Rogers 6486-7. The precession given in the catalogue for this double star is correct. Nevertheless the large motion assigned, $-0^s.095$, is again due to the use of a precession one-tenth of a second too great.

Cincinnati, 1897 *March*.

GEOGRAPHICAL POSITION OF THE OBSERVATORY OF THE CATHOLIC UNIVERSITY, WASHINGTON, D.C.,

By Rev. G. M. SEARLE.

The latitude and longitude of this Observatory have recently been more accurately determined by means of the position of a spire of one of the other buildings on the grounds, which is visible from the new U.S. Naval Observatory.

The values for this point, relatively to the Naval Observatory and other well-determined points, were obtained by careful triangulation, and kindly furnished by Prof. Harkness. From this spire the position of the dome and meridian-circle of this Observatory were determined by triangulation on the grounds, with the following result, for the dome:

Latitude 38° 56′ 14″.8 , Longitude $5^h\ 8^m\ 0^s.00$ W. from Gr.

The circle is about $0^s.012$ to the west of this. The dome was built on the 77th Greenwich meridian as nearly as possible, by means of accurate Coast Survey maps, at an estimated latitude of 38° 56′ 15″.

EPHEMERIS OF D'ARREST'S PERIODIC COMET FOR THE COMING APPEARANCE,

By G. LEVEAU. (*Bulletin Astronomique* for January 1897).

Paris Mean Midnight.

1897	α	Daily Motion	δ	Daily Motion	Br.
	h m s	m s	° ′	′	
Mar. 18.5	20 19 13	+3 19	−8 52.7	+ 7.7	
22.5	32 32	3 21	8 21.0	8.3	0.13
26.5	46 0	3 23	7 47.0	8.8	
30.5	20 59 36	3 25	7 10.8	9.4	0.15
Apr. 3.5	21 13 19	3 27	6 32.6	9.8	
7.5	27 8	3 28	5 52.7	10.2	0.17
11.5	41 2	3 29	5 11.3	10.6	
15.5	21 55 0	3 30	4 28.7	10.8	0.19
19.5	22 9 3	3 31	3 45.1	11.0	
23.5	23 9	3 32	3 0.8	11.1	0.21
27.5	37 17	3 32	2 16.2	11.2	
May 1.5	22 51 25	3 32	1 31.6	11.1	0.23
5.5	23 5 32	3 32	0 47.3	11.0	
9.5	19 37	3 31	−0 3.6	10.8	0.24
13.5	33 38	3 30	+0 39.1	10.5	
17.5	23 47 35	3 28	1 20.5	10.1	0.25
21.5	0 1 26	3 27	2 0.4	9.7	
25.5	0 15 10	+3 25	+2 38.4	+ 9.2	0.26
May 29.5	0 28 46	+3 23	+3 11.3	+8.6	
June 2.5	42 13	3 19	3 47.8	8.0	0.26
6.5	0 55 26	3 16	4 18.7	7.3	
10.5	1 8 27	3 13	4 46.9	6.6	0.26
14.5	21 16	3 10	5 12.2	5.8	
18.5	33 50	3 5	5 34.5	5.1	0.26
22.5	46 6	3 1	5 53.7	4.3	
26.5	1 58 6	2 57	6 9.6	3.5	0.25
30.5	2 9 47	2 52	6 22.3	2.7	
July 4.5	21 8	2 47	6 31.7	1.9	0.24
8.5	32 9	2 42	6 37.8	1.1	
12.5	42 49	2 37	6 40.7	+0.2	0.23
16.5	2 53 7	2 31	6 40.3	−0.6	
20.5	3 3 1	2 25	6 36.6	1.4	0.22
24.5	12 31	2 19	6 29.8	2.2	
28.5	21 36	2 12	6 19.9	3.0	0.21
Aug. 1.5	30 14	2 5	6 7.0	3.7	
5.5	3 38 25	+1 59	+5 51.1	−4.5	0.20

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OBSERVATIONS OF THE SATELLITES OF *MARS* DURING THE OPPOSITION OF 1896,

By J. M. SCHAEBERLE.

The present series of observations were made with the aid of a specially constructed device, which enables the observer to refer all his measures directly to the center of the visible disk of a planet near opposition. A brief description of this device will be necessary, in order that some idea may be obtained as to the degree of accuracy which should be assigned to the present measures.

A strip of thin plane glass, with beveled edges, was wedged into a dove-tailed depression cut in one face of an annular brass ring of such thickness that, when the ring was fastened to the eyepiece cell and the latter screwed into the required position, the face of the glass was close to the spider-lines in the principal focal plane. The glass was first flooded with a solution of india-ink, and the latter allowed to dry. The ring was then placed in a lathe and, with the aid of a pointed tool, a concentric annular ring of the ink surface was removed,* one edge of the glass being nearly tangent to the external diameter of this ring. The internal diameter was made slightly less than the computed diameter of *Mars's* focal image as formed by the 36-inch refractor. At the center of this inner disk a minute circle of ink was also removed. Directly over the center of this minute circle, and close to the surface of the same, a spider-line was stretched approximately at right angles to the edge of the glass, and permanently fastened to the brass ring with cement or wax. Several rings of thin card-board inserted between the flange of the eyepiece cell and the sliding plate (into which the cell screws) act as a clamp to prevent the cell from turning after it has been set, so that the auxiliary spider-line is normal to the parallel micrometer and fixed wires in the focal plane. The sliding plate (carrying the device) is next shifted until the fixed wire as seen through the eyepiece is directly over the center of the minute circle; the plate is then securely clamped to the micrometer-box for the remainder of the night's work.

In observing *Mars* only a narrow annular ring of light from the circumference of the planet and the minute central circle of light were visible, the remainder of the illuminated surface being occulted by the circle of ink. A slight deviation from a concentric position was at once made glaringly apparent to the observer.

On Nov. 28 I used a piece of *red* glass; on Dec. 4 a *yellow* tinted glass, and finally, I found that thin *colorless* glass gave the best satisfaction. This was used on Dec. 10 and Dec. 19.

In order to avoid any appreciable errors due to parallax (as the glass plate is slightly beyond the focal plane) the occulting disk should be in the center of the field of view of the eyepiece.

In the following observations I have already applied the phase-corrections, using the data given by Marth.

As the maximum value of the error in position-angle, due to defective illumination, is only about 0°.03 for these observations, I have neglected the correction for phase in this coordinate. To the measured distances the following corrections have already been applied:

Phase-Corrections to the Measured Distances.

Date	1st Quadrant	3d Quadrant
Nov. 28	+0.07″	−0.07″
Dec. 4	+0.02	−0.02
5	+0.02	−0.02
10	0.00	0.00
19	−0.02	+0.02

Usually the field of view (not covered by the glass strip) was bright enough to show the wires as dark lines within one or two diameters of the planet, and *Phobos* was always observed without artificial illumination; as a rule it became invisible before its distance from the planet was as small as the distance of the nearest point of the edge of the glass strip.

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* If a lathe is not available, a pair of fine dividers can be used to remove the circles of ink. A speck of card-board glued to the glass will serve as a support to keep the stationary leg of the dividers from slipping; the puncture of this card-board, by the stationary leg, forms the minute central circle. The annular ring of clear glass should be about 5″ in width; a greater width would result in the occultation of *Phobos*, by the glass, before the satellite became invisible in the clear part of the field.

An occasional glance at the minute central circle, while the observations are being made, will at once shew whether any accidental shifting of either of the two of these intersecting wires has taken place.

The zero of the circle was determined for the auxiliary wire, and the latter then revolved until it passed through the satellite when *Mars* was central with the occulting disk. The distance was at once found by taking the difference between the reading on the satellite and the reading of the coincidence with the wire passing through the center of the minute circle.

In a rapidly moving body like *Phobos* it is evidently an advantage to be able to measure both coordinates at each bisection. Each tabulated measure is, with a few exceptions, the mean of several observations taken in rapid succession. The number of observations in each set is given in the column headed "No. of Comp." The magnifying power for all observations was 320 diameters.

Standard Pacific Time	Position Angle	No. of Comp.	Distance from Center	No. of Comp.	Remarks
			Deimos. — 1896 Nov. 28.		
h m s	°		″		
9 49 11	240.70	4	41.71	4	Poor seeing, and telescope swaying badly.
10 6 54	241.50	4	44.00	4	
10 25 8	241.14	5	45.80	5	
10 57 33	241.62	6	49.93	6	
11 24 16	240.00	6	52.36	6	
11 49 0	240.10	6	53.84	6	
12 14 0	239.73	3	54.61	3	
12 33 33	240.23	3	55.55	3	
12 51 0	240.27	3	56.20	3	
13 10 11	240.05	3	57.06	3	Instrument reversed
13 43 17	239.40	1	58.25	3	
13 58 0	. .	–	57.73	3	
14 9 30	. .	–	57.05	3	
14 18 0	240.10	1	. .	–	
14 25 2	. .	–	56.97	3	
14 36 40	. .		56.92	2	
14 41 45	239.10	1	. .	–	
14 51 10	. .	–	56.12	1	
15 4 57	. .	–	54.93	3	
15 25 33	240.10	–	. .	–	
15 36 21	. .	–	53.14	4	
			Phobos. — 1896 Nov. 28.		
14 59 37	240.00	–	23.25	4	*
15 16 53	. .	–	22.01	3	
			Phobos. — 1896 Dec. 4.		
8 20 33	239.78	3	22.21	3	
8 29 23	240.91	3	23.22	3	
8 36 27	240.11	3	23.50	3	
8 46 7	239.25	3	23.91	3	
8 57 28	239.01	3	23.04	3	
9 5 5	238.18	3	22.62	3	
9 12 50	238.28	3	21.70	3	
9 22 57	238.40	1	20.14	1	
11 51 32	61.68	2	19.25	2	*Phobos* in 1st quadrant; obs. interrupted, finally stopped by fog.
12 4 10	61.9	1	20.67	1	
12 17 22	61.28	2	21.20	2	
			Deimos. — 1896 Dec. 4.		
9 55 32	58.45	3	37.14	3	†
			Deimos. — 1896 Dec. 5.		
h m s	°		″		
13 31 13	57.37	3	55.22	3	Fog all evening until after midnight
13 46 3	57.87	3	54.02	3	
14 3 32	58.47	3	53.09	3	
14 12 12	58.30	3	52.31	3	
14 22 25	57.80	3	51.92	3	
14 36 35	57.13	3	50.25	3	
14 51 20	57.3	1	48.45	1	
15 15 55	57.1	1	45.22	1	Obs. stopped by fog
15 22 0	. .	–	44.49	3	
			Deimos. — 1896 Dec. 10.		
8 47 8	61.40	3	35.80	3	Cloudy
9 1 8	60.80	3	38.20	3	
9 18 15	60.43	3	40.14	3	
			Phobos. — 1896 Dec. 10.		
9 44 52	238.77	3	22.02	3	
10 2 10	238.75	4	23.12	4	Stopped by clouds
			Phobos. — 1896 Dec. 19.		
7 47 17	238.25	3	20.47	3	
7 54 13	238.08	3	21.37	3	
8 0 30	236.75	3	21.80	3	
8 8 20	236.98	3	22.51	3	
8 15 52	236.21	3	22.70	3	
8 23 23	235.58	3	22.57	3	
8 31 2	235.85	3	22.32	3	
8 39 35	234.81	3	21.87	3	
8 49 38	234.35	3	20.50	3	
8 57 27	234.1	1	19.40	3	
9 1 52	. .		18.72	3	
9 8 25	. .		17.74	2	
			Deimos. — 1896 Dec. 19.		
9 31 17	56.63	3	56.26	3	
9 46 22	56.30	3	55.51	3	
10 2 55	56.11	3	53.56	3	
10 28 32	56.23	2	52.35	3	

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* Whenever during the night both satellites were under observation at the same instant, both could be occulted by the wire passing through the center of the disk.

† There is a bright object-glass ghost just where *Deimos* is, making observations very difficult. Sky thick with fog (after 10 P.M.) until near midnight, when it cleared for about half an hour.

Lick Observatory, University of California, 1897 *March* 4.

OBSERVATIONS OF VARIABLE STARS OF LONG PERIOD,

By EDWIN F. SAWYER.

100. *T Ceti.*

Only 6 scattering observations obtained, 1895 Sept. 21–1896 Jan. 3. At the first date it was = 10 *U.A. Ceti*, or $6^{M}.2$. Its brightness faded, and at last date was 3 steps <28 *U.A. Ceti* and = 21 *U.A. Ceti*, or $6^{M}.9$. No distinct phase observed.

806. *o Ceti.*

Observed 18 times, 1895 Jan. 2–Feb. 22. On Jan. 2 it was 4 steps <S.DM. 4°379, or $8^{M}.2$. Increase quite rapid until, when last seen, it was 4 steps >λ *Ceti* and = ξ *Ceti*, or $4^{M}.4$; maximum not reached.

845. *R Ceti.*

Observed 16 times, 1895 Jan. 11–Feb. 16. Maximum 1895 Jan. 28. Comparison-stars not yet identified.

893. *U Ceti.*

Faint maximum passed about 1895 Nov. 20(?) Five scattering observations, 1895 Nov. 11–Dec. 16. At first date, 5 steps <S.DM. 13°502, or $8^{M}.6$. It brightened to $8^{M}.3$ on Nov. 15. By Dec. 16 it had faded 3 steps. No observations between Nov. 21 and Dec. 14.

906. *R Trianguli.*

Observed 23 times, 1894 Dec. 22–1895 Feb. 24. Maximum passed Feb. 16, at $6^{M}.2$. Comparison-stars not yet identified.

1072. *ρ Persei.*

Observed 13 times, 1895 Jan. 23–Mar. 16; 49 times 1895 Aug. 19–1896 April 15. On Jan. 23, at normal brightness. From Feb. 10 it faded 3–4 steps, passing minimum Feb. 20, and rapidly brightened after Feb. 23. Aug. 19 again normal, remaining unchanged to 1896 Feb. 21, then faded 3 steps, passing minimum Mar. 7. Rapid recovery followed; no further change to end of observations April 15.

2100. *U Orionis.*

Observed 20 dates, 1895 Jan. 23–Mar. 30. At first date = DM. 20°1168, or $8^{M}.6$. Increase rapid and regular to maximum on Feb. 25, when it was 5 steps <DM. 19°1110 and 2 steps >20°1156, or $6^{M}.8$. At last observation, Mar. 30, 4 steps <19°1106, or $7^{M}.2$.

2170. *S Leporis.*

Observed on 26 dates, 1894 Nov. 19–1895 Mar. 21. On first date, 3 steps >Gould G.C. 7339 and 2–3 steps <7298, or $7^{M}.6$. Stationary till Jan. 23, then a slight increase, with a faint and uncertain maximum about Feb. 7. Decrease of 3–4 steps after Mar. 3, and then no change to Mar. 21.

3493. *R Leonis.*

Observed 13 dates, 1895 Jan. 30–May 10. On first date, 5 steps <DM. 12°2090, 1 step >12°2095, or $6^{M}.8$. Rapid increase to bright maximum on Mar. 1. It was then 3 steps <8°2301 and 2–3 steps >13°2183, or $5^{M}.3$. Decrease also rapid. When last seen, it was 3 steps <11°2108, or $8^{M}.1$.

3796. *U Hydrae.*

Seven scattering observations, 1895 Feb. 15–May 10. Brightness constant.

4521. *R Virginis.*

Observed 10 dates, 1895 Apr. 20–June 14. On first date, 5 steps <DM. 8°2634, or $8^{M}.5$. Increase rapid, and maximum passed May 27, when it was 3 steps >8°2619 and 3 steps <9°2648, or $7^{M}.0$. When last seen it was 5 steps <8°2617 and = 8°2616, or $7^{M}.6$.

4847. *S Virginis.*

Observed 9 dates, 1895 May 16–June 23. On first date, 5 steps >S.DM. 6°3839 and 1–5 steps <5°3706, or $6^{M}.7$. Maximum apparently passed about May 25, although the series began too late for certain determination, the rise observed being only 1–2 steps. When last seen it was 1 step <6°3839 and 5 steps >5°3713, or $7^{M}.4$.

5501. *S Serpentis.*

Observed 10 dates, 1895 May 16–July 14. At first date, 5 steps <DM. 14°2868, or $9^{M}.0$. Maximum reached June 13, when it was 1–2 steps >14°2866 and 4–5 steps <15°2845, or $7^{M}.7$. At last date, 4–5 steps <14°2866, or $8^{M}.3$.

5667. *R Coronae.*

At normal brightness 1895 Feb. 26. After several minor fluctuations of 2–3 steps, it suddenly faded July 18, and passed minimum about July 26, being then 4 steps <DM. 28°2469, or $8^{M}.3$. Rapid recovery after August, until on Oct. 10 it was nearly at its normal brightness again, or between 32°2621 and 30°2682. Twenty-seven observations in all.

5758. *X Herculis.*

Observed on 31 dates, 1895 Apr. 16–Dec. 14. When first seen it was near maximum, which was reached probably about May 1. A second maximum, on Aug. 5, was well determined; and a minimum, June 30, was also well marked.

5912. *g Herculis.*

Observed on 34 dates, 1895 April 16–Nov. 6. The fluctuations during the year were within narrow limits. A faint maximum was passed June 12, and a somewhat brighter one about Sept. 30. The only minimum, but faintly indicated, was passed about July 30.

6733. *R Scuti.*

A good series of observations was obtained, 53 in number, 1895 May 16–Dec. 16. A bright maximum was passed July 13, and a bright minimum Aug. 9. After a rapid recovery a second bright maximum was reached Aug. 26, followed by rapid fall to a very faint minimum Oct. 10. After a rapid rise a very bright maximum was reached Nov. 26.

6791. *R Lyrae.*

Observed on 88 dates, 1895 April 16–1896 Jan. 11. The fluctuations during the year were somewhat erratic. Ignoring several minor fluctuations in drawing the curves the following phases were more or less accurately determined: maxima, June 6, Aug. 21 and Oct. 26; minima, May 7, July 9, Sept. 16 and Dec. 9.

7751. *W Cygni.*

Observed on 33 dates, 1895 May 13–1896 Feb. 8. Observed maxima, 1895 Sept. 24 and 1896 Jan. 5; minima, July 15 and Nov. 25.

Brighton, Mass., 1897 *Feb.* 22.

FILAR-MICROMETER OBSERVATIONS OF COMETS,

MADE WITH THE 26-INCH EQUATORIAL OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

BY ORMOND STONE AND H. R. MORGAN.

1896 Charlottesville M.T.		✱	No. Comp.	☄ − ✱ Δα	☄ − ✱ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ	Obs.
			Comet *d* 1896 (Giacobini).							
	h m s			m s	′ ″	h m s	° ′ ″			
Sept. 6	10 42 7	1	14 , 4	+0 31.79	+2 19.3	17 14 56.27	− 7 52 11.8	9.638	0.755	S
			Comet 1889 V = *e* 1896 (Brooks).							
Aug. 30	11 35 20	2	25 , 4	−1 50.85	+6 11.4	22 21 24.83	−19 8 40.7	*n*8.151	0.868	S
Sept. 6	11 53 58	3	35 , 4	+0 51.62	−0 52.7	22 16 42.82	−19 2 20.4	*n*8.771	0.866	S
			Comet *f* 1896 (Perrine).							
Nov. 5	8 28 54	4	*d*5 , 4	−0 13.11	+3 17.6	20 16 43.88	+22 50 0.2	9.563	0.494	S
5	9 14 52	5	*d*5 , 2	+0 25.36	+1 9.8	20 16 40.72	+22 48 26.2	9.650	0.573	S
			Comet *g* 1896 (Perrine).							
Dec. 11	9 17 51	6	*d*6 , 4	−0 12.54	−4 50.6	1 12 2.67	+ 5 15 18.7	9.254	0.680	S
1897 Jan. 25	9 24 16	7	16 , 4	+1 50.75	−2 42.4	1 51 15.08	− 0 10 15.7	9.042	0.734	S
29	8 6 21	8	32 , 4	+0 26.41	+2 33.5	5 2 57.77	+ 0 9 54.2	*n*8.571	0.730	S
	9 7 22	8	43 , 8	+0 32.33	+2 46.7	5 3 3.69	+ 0 10 7.4	8.932	0.730	M
30	8 10 11	9	52 , 8	−0 41.91	−7 57.7	5 5 15.09	+ 0 15 13.7	*n*8.431	0.729	M
	10 27 37	9	48 , 4	−0 26.40	−7 27.6	5 6 0.63	+ 0 15 43.8	9.378	0.730	S
Feb. 3	8 30 37	11	*d*8 , 6	+0 2.24	+5 8.3	5 16 28.23	+ 0 38 42.1	8.387	0.725	M
23	11 2 31	12	*d*2 , 2	+0 6.30	−0 0.5	6 3 56.14	+ 2 42 35.5	9.543	0.714	S
	11 32 4	12	*d*1 , 1	+0 10.22	+0 2.0	6 4 0.06	+ 2 42 38.0	9.586	0.716	M

Mean Places for 1896.0 and 1897.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	17 14 21.47	+3.01	− 7 54 25.0	− 6.1	½ (Munich I. 13806 + Schj. 6181)
2	22 23 11.31	+4.37	−19 15 12.0	+19.9	½ (Munich II, 12495 + Cincinnati Z.C. 3785)
3	22 15 43.78	+4.42	−19 1 46.8	+19.1	¼ (2 Radcliffe 6001 + Munich I + Munich II)
4	20 16 54.71	+2.28	+22 46 24.0	+18.6	Becker. Berlin A.G. Catal. 7656
5	20 16 13.08	+2.28	+22 46 57.9	+18.6	Becker. Berlin A.G. Catal. 7648
6	1 12 11.01	+4.20	+ 5 20 12.1	+27.2	½ (Schj. 408 + Boss, Albany A.G. Catal. 353)
7	4 46 52.52	+1.81	− 0 7 36.6	+ 3.3	Kortazzi. Nikolajew
8	5 2 29.50	+1.86	+ 0 7 18.1	+ 2.6	W. Bessel, Zone 48
9	5 6 25.15	+1.88	+ 0 23 8.8	+ 2.6	W. Bessel. Zone 39
10	5 15 21.78	+1.88	+ 0 29 19.7	+ 2.2	W. Bessel, Zone 48
11	5 16 24.11	+1.88	+ 0 33 31.4	+ 2.2	Comp. with ✱10 by M.
12	6 3 47.98	+1.86	+ 2 42 36.0	0.0	Micr.-comp. with ✱15 by M.
13	6 3 35.36	+1.86	+ 2 30 56.9	− 0.1	Boss. Albany A.G. Catal. 2041
14	6 3 35.00	+1.86	+ 2 36 1.3	0.0	Micr.-comp. with ✱13 by M.
15	6 3 41.15	+1.86	+ 2 40 53.1	0.0	Micr.-comp. with ✱14 by M.

The following corrections have been applied to reduce to common epoch: Sept. 6, Comet *d*, $\Delta\delta$ −0″.8, for −2m.0; Nov. 5. first obs., $\Delta\alpha$ −0s.57, for +8m.5; Nov. 5, second obs., $\Delta\alpha$ +0s.65, for −9m.5; Dec. 11, $\Delta\delta$ +18″.8, for −18m.3; Jan. 25, $\Delta\delta$ −0″.7, for −3m.7: Jan. 29, first obs., $\Delta\delta$ +0″.6, for +2m.8; Jan. 29, second obs., $\Delta\delta$ +3″.3, for +14m.6; Jan. 30, second obs., $\Delta\delta$ +0″.5, for −2m.1; Feb. 3, $\Delta\delta$ −1″.6, for +6m.3; Feb. 23, first obs., $\Delta\delta$ +0″.8, for +3m.3; Feb. 23, second obs., $\Delta\delta$ +2″.0, for +8s.4.

OBSERVATIONS OF COMET 1896 VII AND MINOR PLANETS,

MADE AT THE SAYRE OBSERVATORY, SOUTH BETHLEHEM, PA.,

By J. H. OGBURN.

South Bethlehem M.T.		*	No. Comp.	Planet — * $\Delta\alpha$	Planet — * $\Delta\delta$	Planet's Apparent α	Planet's Apparent δ	log *p* for α	log *p* for δ
				Sappho (80).					
1896	h m s			m s	′ ″	h m s	° ′ ″		
Oct. 31	8 18 56	1	6 , 4	+2 6.66	−3 42.6	1 35 50.22	+11 51 26.2	*n*9.454	0.655
Nov. 2	9 28 4	2	6 , 4	+2 21.56	−6 21.1	1 31 34.40	11 27 0.2	*n*9.168	0.638
6	10 20 9	3	4 , 5	−3 5.68	−5 6.8	1 32 23.28	+10 41 18.5	*n*7.792	0.642
				1894 *AZ* (387).					
Nov. 5	11 59 51	4	12 , 6	+0 1.90	−3 49.5	3 33 33.90	− 7 47 14.4	*n*8.772	0.818
6	11 19 51	5	8 , 6	−0 28.30	−1 1.3	3 32 41.81	− 7 50 6.7	*n*8.752	0.817
8	10 14 16	5	6 , 4	−2 13.58	−6 11.4	3 30 56.57	− 7 55 16.9	*n*9.362	0.911
14	11 45 46	6	5	−1 35.11	+5 22.2	3 25 27.97	− 8 5 50.2	*n*7.049	0.821
				Flora (8).					
Dec. 14	7 50 46	7	7	−0 39.04	−2 31.1	4 27 29.57	+14 54 25.4	*n*9.516	0.635
				☄ *g* 1896 (Perrine).					
1897 Jan. 5	7 56 17	8	8	−0 13.05	−1 31.8	3 38 59.06	− 0 38 40.8	*n*8.879	0.764
6	8 14 50	9	8 , 12	−0 49.33	−1 51.4	3 43 27.38	− 0 41 56.6	*n*8.616	0.764
7	8 31 43	11	10	−0 14.41	+2 35.7	3 47 19.11	− 0 44 34.4	*n*7.957	0.765
				Psyche (16)					
Feb. 19	8 36 50	12	9 , 6	−0 21.80	+9 30.2	10 27 4.17	+ 9 59 29.5	*n*9.584	0.693
24	10 1 36	13	6	+0 14.68	+2 47.4	10 23 3.37	+10 26 51.3	*n*9.160	0.662
25	8 39 35	14	4	. .	+1 45.3	. . .	+10 31 51.9	. .	0.684
Mar. 3	8 0 46	15	4 , 6	−1 11.26	−3 22.4	10 17 40.75	+11 2 58.5	*n*9.557	0.684
4	8 44 6	16	6	+0 25.59	−4 47.5	10 16 54.07	+11 8 10.3	*n*9.471	0.655

Mean Places for 1896.0 and 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 33 39.14	+4.42	+11 54 39.6	+29.2	⅓ (2 Yarnall + Munich 1)
2	1 32 8.42	+1.42	+11 32 52.1	+29.2	Brussels
3	1 35 24.52	+4.44	+10 45 56.3	+29.0	Weisse-Bessel 587
4	3 33 24.63	+4.37	− 7 43 49.0	+24.1	Gould A.C. 4000
5	3 33 5.78	+4.33 +4.37	− 7 49 29.4	+24.0 +23.9	Gould A.C. 3988
6	3 26 58.60	+4.48	− 8 11 35.6	+23.2	Yarnall 1505
7	4 28 3.40	+5.21	+14 56 41.7	+11.8	Yarnall 1997
8	3 39 40.42	+1.69	− 0 37 14.8	+ 5.8	½ (Gould 4127 + Pulkowa 55, 542)
9	3 44 15.01	+1.70	− 0 40 10.8	+ 5.6	½ (Göttingen + Munich 1)
10	3 47 1.85	+1.70	− 0 57 51.7	+ 5.5	Gould A.C. 4283
11	3 48 1.84	+1.71	− 0 47 15.6	+ 5.5	Micrometer-comparison with *10
12	10 27 23.33	+2.64	+ 9 50 11.5	−12.2	ρ *Leonis, American Ephemeris*
13	10 22 16.01	+2.68	+10 24 16.0	−12.1	Weisse-Bessel 345
14	10 19 35	. .	+10 30 18.7	−12.1	Yarnall 4425
15	10 18 52.27	+2.74	+11 6 33.0	−12.1	½ (Yarnall 4417 + Brussels 4327)
16	10 16 25.74	+2.74	+11 13 9.7	−11.9	½ (Yarnall 4401 + Brussels 4309)

OBSERVATIONS OF SUNSPOTS,

MADE AT THE BOSTON UNIVERSITY OBSERVATORY.

BY L. O. TILLSON AND F. J. H. MANSFIELD.

W. M. T.	Groups			Spots			Def.
	N.	S.	Total	N.	S.	Total	
1896 Dec. d h							
1 0	2	1	3	5	2	7	fair
3 0	2	1	3	5	3	8	poor
3 23	2	2	4	16	7	23	fair
4 23	2	2	4	23	8	31	fair
7 23	2	2	4	4	12	16	poor
9 23	2	2	4	4	13	17	poor
13 23	0	2	2	0	10	10	fair
16 23	0	2	2	0	14	14	poor
18 23	1	3	4	1	16	17	fair
21 22	1	2	3	13	5	18	poor
23 23	1	0	1	4	0	4	fair
27 22	1	2	3	4	13	17	fair
30 23	0	4	4	0	7	7	fair
1897 Jan.							
2 3	0	3	3	0	6	6	poor
7 3	0	3	3	0	27	27	fair
7 23	0	3	3	0	37	37	fair
8 23	0	3	3	0	37	37	poor
12 23	0	4	4	0	25	25	poor
1897 Jan. d h							
14 23	0	5	5	0	14	14	fair
18 2	0	3	3	0	24	24	fair
18 23	0	2	2	0	4	4	poor
20 0	1	2	3	5	6	11	poor
22 0	1	2	3	21	8	29	fair
24 23	2	0	2	6	0	6	poor
29 0	3	1	4	9	1	10	fair
29 22	3	2	5	11	4	15	poor
Feb.							
1 0	3	2	5	26	9	35	good
8 23	1	1	2	1	5	6	fair
10 0	1	1	2	1	5	6	fair
17 23	1	0	1	14	0	14	good
19 0	1	0	1	?	0	?	poor
23 2	2	0	2	5	0	5	good
24 0	2	1	3	7	2	9	fair
26 0	3	2	5	6	7	13	poor
27 3	3	2	5	7	6	13	fair

North of the equator 12 different groups, containing a total of 101 spots, were observed. South, the numbers were 18 and 129 respectively. Of the spots having nearly symmetrical penumbras when well on the disc, one when on the limb did not have penumbra upon the side next to the limb; three wanted it upon the side removed from the limb, while in four other cases it was wanting upon both sides under the same condition.

In several cases a spot was observed surrounded by a narrow annulus, appearing like a single circular facula. In every such case the spot was small and, save in one instance, showed no penumbra. The annulus was not immediately contiguous to the umbra in any case. The large spot in January was first seen $2^{d}\,2^{h}\,30^{m}$ W.M.T. It then appeared as a very narrow umbra with penumbra upon the east side only. In the notes the remark occurs, "Looks like a depression." At $11^{d}\,22^{h}\,30^{m}$ it was last seen upon the western limb. Its reappearance was first observed $29^{d}\,22^{h}$, and the same note was made as upon Jan. 2 concerning the penumbra and apparent depression. This note was not made concerning any other spot when upon the limb.

OBSERVATIONS OF VARIABLE STARS.—No. 4.

BY W. E. SPERRA.

294. *W Cassiopeae.*

This star was observed eleven times, between 1896 June 10, when it was below $9^{M}.5$, and 1896 Oct. 24, when same magnitude was reached again, indicating a maximum of $8^{M}.3$ on Aug. 15. Owing, perhaps, to the fact that the value of my light-step is only about a third that of Mr. J. A. PARKHURST's, my maximum seems to be more definitely marked than his (*A.J.* 397), and will permit of but little latitude from the date assigned.

2815. *U Geminorum.*

A maximum is indicated for 1896 Dec. 1.5, by the following observations. Magnitudes as usual on BAXENDELL's scale.

	M		M
1896 Nov. 30.50	10.5>	1896 Dec. 1.94	9.2
30.94	9.6	5.91	11.2

4521. *R Virginis.*

Forty observations, from 1896 Feb. 11 to 1896 Aug. 24, indicate a well-defined maximum for 1896 March 15.5, at $6^{M}.4$. A minimum for 1896 May 20, at $10^{M}.9$. Another maximum for Aug. 6, at $6^{M}.1$. The last maximum-curve was quite flat.

4816. *V Virginis.*

Eight observations of this star, between 1896 May 29 and 1896 July 10, indicate the maximum for June 17, at $8^{M}.7$. The brightness of the star at the limiting dates was $9^{M}.2$ and $8^{M}.9$, respectively.

7085. *RT Cygni.*

A series of nineteen observations, extending from 1896 May 29 to 1896 Aug. 28, indicate a maximum for July 8.0, at $6^{M}.9$. At first observation the star was of $9^{M}.5$, and at last $9^{M}.4$. Another series of seventeen observations, from 1896 Nov. 30 to 1897 Mar. 6, yield as the time of maximum 1897 Jan. 10.0. Magnitude at limiting dates same as in preceding maximum.

6636. *U Sagittarii.*

I observed this star forty-six times, between 1896 June 27 and 1896 Nov. 1. Following are the results.

Maxima	Obs.	Minima	Obs.
1896 June 30.54	3	1896 June 27.93	2
July 26.66	2	July 11.15	3
Aug. 2.93	3	17.93	3
30.17	4	Aug. 6.99	2
Sept. 5.96	3	Sept. 3.27	4
Oct. 9.38	4	10.13	3
23.56	2	Oct. 7.01	2
		27.75	3

7124. *η Aquilae.*

Thirty-nine naked-eye observations, between 1896 July 12 and 1896 Nov. 9, yield results as follows:

Maxima	Obs.	Minima	Obs.
1896 July 31.48	2	1896 Aug. 5.98	3
Aug. 29.15	4	Sept. 3.66	3
Sept. 5.57	2	10.09	3
Oct. 3.90	4	Oct. 8.97	3
25.43	1	30.01	3
Nov. 1.69	2		

7137. *X Cygni.*

Fifty-seven observations of this star, from 1896 May 31 to 1896 Dec. 6, yield results below. Several breaks occur in the series.

Maxima	Mag.	wt.	Minima	Mag.	wt.
1896 June 2.1	6.3	$\frac{1}{2}$	1896 June 11.4	6.8	$\frac{1}{2}$
19.3	6.2	$\frac{3}{4}$	28.7	6.8	1
Aug. 7.0	6.2	$\frac{3}{4}$	July 15.0	6.7	1
23.9	6.1	1	Aug. 1.5	6.7	1
			17.0	6.9	$\frac{3}{4}$
			Nov. 6.5	6.9	$\frac{1}{2}$

8598. *U Pegasi.*

1896 Oct. 3; ten observations, from $12^{h}\ 41^{m}$ to $16^{h}\ 21^{m}$, yield as the time of maximum $15^{h}\ 2^{m}$, Gr. M.T.

1896 Oct. 4; six observations, from $12^{h}\ 54^{m}$ to $15^{h}\ 18^{m}$, indicate the time of maximum as $13^{h}\ 45^{m}$, Gr. M.T.

Randolph, Ohio, 1897 *March* 11.

NOTE ON THE DOUBLE STAR μ *VELORUM* (RUSSELL 155),

BY T. J. J. SEE.

In discussing our accumulated observations of double stars, I find from the *Sydney Observations*, which have just come to hand but which were previously inaccessible in this part of the earth, that we were anticipated in the discovery of μ *Velorum* by Mr. RUSSELL of Sydney. He first saw the companion 1880 April 26; the only measure heretofore secured, so far as I can discover, is

t	θ_0	ρ_0		
1880.325	5°.5	2″.81	1*n*	Russell

Our measures give

t	θ_0	ρ_0		
1897.059	62°.7	2″.52	4*n*	See

Assuming that there is no typographical error in the angle given in the *Sydney Observations*, it is clear that we have here a case of rapid direct motion; a change of 57°.2 in 16.72 years implies a period of not far from a century. But the orbit may be very eccentric, and hence this is only a rough estimate. The object deserves measurement annually, as the motion will soon lead to an approximate determination of the orbit.

Lowell Observatory, City of Mexico, 1897 *March* 15.

ON THE MAGNITUDE OF THE VARIABLE STAR η *CARINAE* IN 1897,

BY T. J. J. SEE.

During our recent survey of the double stars in the great nebula and cluster surrounding η *Carinae*, I took occasion to make careful estimates of the magnitude of this remarkable variable. The object has been compared with the most convenient of the stars given for this purpose in the *Uranometria Argentina*, viz: L. 4448, L. 4451, G. 1332, B. 3204, B. 3202. In this way we have obtained the values opposite which may be of interest to astronomers occupied with the study of variable stars.

The color is distinctly reddish, perhaps a shade deeper than that of the neighboring star, A.G.C. 14723, which GOULD calls crimson. The color seemed to be substantially identical with that of the larger component of the double star A.G.C. 14686.

1897 March	7	$7^{M}.60$
	8	7.65
	12	7.54
	13	7.63
	14	7.60
1897 March	10.8	7.60

Lowell Observatory, City of Mexico, 1897 *March* 15.

EPHEMERIS OF COMET 1896 VII,

BY F. RISTENPART.

(Continued from page 92.)

1897 Berlin M.T	App. α h m s	App. δ ° '	log Δ	Br.
Mar. 28.5	7 10 1	+ 5 1.9	0.4586	0.012
30.5	13 48	6.3		
Apr. 1.5	17 34	10.3	.4789	.011
3.5	21 20	13.9		
5.5	25 1	17.0	.4987	.010
7.5	28 47	19.6		
9.5	32 28	21.7	.2179	.009
11.5	36 9	23.3		
13.5	39 48	24.5	0.2364	0.008
15.5	7 43 26	+5 25.2		
Apr. 17.5	7 47 3	+5 25.4	0.2544	0.007
19.5	50 39	25.2		
21.5	54 15	24.5	.2719	.006
23.5	7 57 49	23.4		
25.5	8 1 22	21.9	.2889	.005
27.5	4 54	19.9		
29.5	8 25	17.5	.3054	.005
May 1.5	11 55	14.7		
3.5	8 15 25	+5 11.5	0.3213	0.004

THE COMPANION OF *SIRIUS*,

BY H. S. PRITCHETT.

On March 20 I observed the companion of *Sirius* with the 12½-inch equatorial of the Morrison Observatory. The night was one of the finest I have ever seen in this climate, and the companion was seen by my father and myself. A mean of three settings of the micrometer gave

$$p = 195° \qquad s \text{ (estimated)} = 3\tfrac{1}{2}''.$$

Washington University, 1897 *March* 26.

COMETS OF THE YEAR 1896.

The dates are in Greenwich Mean Time and the Elements only approximate.

Designation	Perihelion	☊ ° '	ω ° '	i ° '	q	φ ° '	Discoverer	Date	Synonym	
I	1896 Jan. 31.84	208 54	358 32	155 45	0.5876	. .	Perrine	Feb. 15	*a* 1896	
II	Mar. 19.3	209 49	201 13	11 20	1.7382	33 18	Javelle	Sept. 26	*b* 1895	Faye's
III	Apr. 17.65	178 16	1 44	55 34	0.5664	. .	Swift	Apr. 13	*b* 1896	
IV	July 10.94	151 2	41 2	88 26	1.1425	. .	Sperra	Aug. 31	*e* 1896	
V	Oct. 25.99	192 6	139 29	11 33	1.4816	41 6	Giacobini	Sept. 4	*d* 1896	Periodic
VI	Nov. 4.16	18 1	343 48	6 4	1.9592	28 0	Javelle	June 20	*c* 1896	1889 V
VII	Nov. 24.60	246 35	163 52	13 39	1.1098	42 38	Perrine	Dec. 8	*g* 1896	Periodic
–	1897 Feb. 8.14	86 18	172 21	146 8	1.0623	. .	Perrine	Nov. 2	*f* 1896	

Two objects 30′ apart, 1° east of sun, were apparently seen by SWIFT 1896 Sept. 20, and suspected by him to be cometary. They were unsuccessfully searched for by HUSSEY and PERRINE on Sept. 21, and on several dates thereafter.

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THE ORBIT OF F.70 *OPHIUCHI*,

BY ERIC DOOLITTLE.

The object of the following investigation has been to ascertain the elements of this orbit which result from a least-square solution based on both angles and distances. Dr. T. J. J. SEE has pointed out that the results from the rigorous discussion of Dr. SCHUR, which were obtained from the position-angles only, violate inadmissibly the observed distances, while the orbit obtained by Dr. SEE, which best represents the distances, is subject to similar perturbations in angle. Both orbits also are greatly in error in representing the position-angles of the past four or five years.

It was therefore scarcely hoped that the following investigation would lead to an orbit which, without the assumption of a disturbing body, would account for the observed motion. Being, however, based upon the same data as the orbit obtained by graphical methods by Dr. SEE, it appears of importance to compare the two orbits, and to select one of them as a basis for determining the probable motion of the unseen body.

The comparison shows that, though the two sets of elements differ considerably, the residuals in angle and distance from the two orbits are nearly the same until the year 1883, or during a period of over one hundred years. This remarkable agreement of the residuals for so long a time cannot be construed to indicate that the orbits published by Dr. SEE are liable to much uncertainty, because in this case both orbits fail to represent the motion observed, and also because after the year 1883 the two sets of residuals rapidly begin to differ, those of Dr. SEE increasing to seven degrees, and those of the orbit here published remaining nearly zero.

The first step of the following investigation was to substitute the coordinates $x = \rho\cos\theta$, $y = \rho\sin\theta$, in the equation of the apparent orbit,

$$Ax^2 + 2Hxy + By^2 + 2Gx + 2Fy + 1 = 0$$

The annual means formed by Dr. SEE were in general used, but in some cases half-yearly means were formed. There resulted one hundred and twelve equations of condition which were solved for the five coefficients, A, H, B, etc. The residuals arising from the solution clearly indicated systematic errors from some source, and when the elements were obtained by the method of KOWALSKY,* (Dr. SEE's *Evolution of the Stellar Systems*, p. 49), similar residuals appeared in θ and ρ.

These elements were the following:

$$\begin{array}{rcl|rcl} e & = & 0.5001 & i & = & 56^\circ.65 \\ \Omega & = & 126^\circ.44 & P & = & 88.681 \text{ yrs.} \\ \lambda & = & 166^\circ.22 & T & = & 1895.51 \end{array}$$

$$a = 4''.5288$$

As the residuals which resulted were inadmissible, the individual observations were next weighted and combined into sixteen normal places, by the formula,

$$\theta \text{ or } \rho = \alpha + \beta t + \gamma t^2$$

The differential corrections to the elements were determined from these normal places by the usual methods. The results are as follows, the elements of Dr. SEE being written also for comparison:

ELEMENTS.

$$\begin{array}{rcl|rcl} e & = & 0.4998 & i & = & 56^\circ.72 \\ \Omega & = & 126^\circ.05 & P & = & 86.6660 \\ \lambda & = & 166^\circ.58 & T & = & 1895.517 \end{array}$$

$$a = 4''.5227$$

SEE'S ELEMENTS.

$$\begin{array}{rcl|rcl} e & = & 0.500 & i & = & 58^\circ.42 \\ \Omega & = & 125^\circ.7 & P & = & 88.3954 \\ \lambda & = & 161^\circ.75 & T & = & 1896.4661 \end{array}$$

$$a = 4''.548$$

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* The Period and Periastron Passage were obtained from the geometrical elements by a solution of 112 equations of the form

$$\Delta T = x \,.\, \Delta M + M \,.\, \Delta x$$

in which ΔT and Δx are corrections to assumed values of T and $\frac{1}{n}$ respectively, and ΔM is the difference between the values of M computed from the observed θ's, and from the assumed values of n and T.

The residuals from the two sets of elements are given in the table below, where θ_s and ρ_s refer to Dr. SEE's orbit.

It will be observed that the residuals in distance are, on the whole, smaller than those obtained by the graphical method, though the difference is slight. The residuals throughout are strikingly similar, especially from 1834 to 1883; the new orbit, however, satisfies well the observations of the past ten years. It is probably not unreasonable to conclude that a direct reduction of the material which is available by the methods of least-squares will not lead to results which are free from systematic errors.

It may be remarked that if the new orbit is used in the construction of *Curve A*, of Dr. SEE's article (*Astronomical Journal*, no. 363), the period of the disturbing body will be increased by a small amount.

Date	$\theta_0 - \theta_s$	$\theta_0 - \theta$	$\rho_0 - \rho_s$	$\rho_0 - \rho$	Date	$\theta_0 - \theta_s$	$\theta_0 - \theta$	$\rho_0 - \rho_s$	$\rho_0 - \rho$
	°	°	″	″		°	°	″	″
1779.77	−8.1	−7.8	. .	. .	1857.52	0.0	−0.1	+0.05	+0.01
1781.74	+4.4	+4.5	−0.11	−0.12	1858.39	−1.1	−0.9	−0.16	−0.19
1802.34	+0.7	+4.2	. .	. .	1859.66	−0.4	−0.5	+0.18	+0.14
1804.42	−3.2	−2.8	. .	. .	1860.70	−0.3	−0.5	+0.40	+0.35
1819.64	+5.1	+5.1	. .	. .	1861.67	−0.5	−0.7	−0.14	−0.18
1820.77	+0.8	+0.4	. .	. .	1862.59	0.0	−0.1	+0.09	+0.03
1821.74	+2.7	+2.1	. .	. .	1863.54	+0.2	−0.1	+0.01	−0.06
1822.42	+2.0	+1.4	+0.72	+0.57	1864.54	+0.8	+0.4	−0.06	−0.10
1822.64	+1.7	+1.1	. .	. .	1865.50	+0.2	0.0	−0.03	−0.08
1825.56	+3.2	+2.5	−0.37	−0.35	1866.43	+0.5	+0.3	+0.11	+0.04
1827.02	+2.8	+1.9	−0.28	−0.30	1867.50	+0.4	+0.4	+0.14	+0.08
1828.71	+0.7	−0.2	−0.22	−0.26	1868.65	+1.3	+1.1	+0.05	0.00
1829.59	+0.4	−0.6	−0.15	−0.16	1869.80	+1.3	+1.2	−0.03	−0.07
1830.57	0.0	−0.7	+0.24	+0.22	1870.51	−0.4	−0.3	−0.08	−0.11
1831.58	−0.4	−1.2	+0.36	+0.33	1871.56	+1.3	+1.2	−0.03	−0.07
1832.62	−0.8	−1.3	+0.08	+0.06	1872.51	+1.4	+1.1	−0.01	−0.05
1833.42	−0.3	−1.2	+0.34	+0.34	1873.56	+0.4	0.0	0.00	−0.05
1834.55	−1.2	−1.5	+0.12	+0.09	1874.61	+2.7	+2.3	+0.01	−0.03
1835.60	−0.2	−0.4	+0.07	+0.04	1875.61	+1.7	+1.5	−0.04	0.00
1836.52	−1.1	−1.1	+0.20	+0.16	1876.57	+1.5	+1.2	+0.07	+0.02
1837.64	−1.0	−1.2	+0.21	+0.18	1877.60	+1.8	+1.7	+0.02	−0.01
1838.59	−1.4	−1.8	+0.32	+0.29	1878.58	+2.5	+2.2	+0.03	+0.01
1839.58	−1.5	−1.6	+0.25	+0.23	1879.57	+2.3	+2.1	+0.12	+0.08
1840.47	+0.3	+0.1	−0.09	−0.10	1880.59	+2.0	+1.8	−0.01	−0.03
1841.64	−1.1	−1.4	+0.10	+0.08	1881.56	+3.9	+3.9	+0.06	+0.04
1842.57	−0.5	−0.9	−0.01	−0.02	1882.60	+3.3	+3.6	+0.16	+0.14
1842.60	−0.8	−0.9	+0.20	+0.17	1883.62	+2.4	+2.8	+0.11	+0.09
1843.55	−1.3	−1.3	−0.06	−0.08	1884.56	+2.0	+2.4	+0.07	+0.07
1844.44	−1.4	−1.4	+0.01	0.00	1885.61	+0.7	+1.8	+0.02	+0.04
1845.48	−0.9	−1.1	−0.03	−0.04	1886.61	−0.9	+0.7	−0.07	−0.04
1846.46	−1.6	−1.7	+0.07	+0.05	1887.68	−1.0	+0.6	−0.09	−0.07
1847.47	−1.0	−1.2	+0.16	+0.13	1888.62	−2.1	−0.1	+0.07	+0.06
1848.38	−1.0	−1.3	+0.13	+0.09	1889.53	−2.3	+0.9	−0.01	0.00
1849.39	−0.3	−0.5	−0.03	−0.01	1890.57	−2.4	+0.6	+0.04	0.00
1850.55	−1.0	−1.1	+0.13	+0.10	1891.59	−3.6	−0.4	−0.02	+0.01
1851.54	−1.0	−1.3	−0.04	−0.06	1892.52	−3.5	+0.8	−0.05	−0.01
1852.69	−0.6	−0.7	0.00	−0.02	1893.62	−2.3	+1.0	−0.10	−0.05
1853.57	+0.1	+0.1	−0.11	−0.13	1894.69	−4.8	+0.5	−0.03	+0.01
1854.48	−0.7	−0.8	−0.11	−0.13	1895.32	−7.0	−0.2	−0.09	−0.05
1855.52	+0.3	+0.2	+0.04	+0.01	1895.64	−5.6	−0.1	−0.12	−0.06
1856.43	−0.4	−0.6	0.00	−0.04	1896.62	−4.6	+0.5	−0.16	+0.06

Flower Observatory, 1897 *March* 25.

NOTES ON VARIABLE STARS, — No. 17,

BY HENRY M. PARKHURST.

Except when specially mentioned, all the determinations of maxima and minima in these Notes have been obtained from the formula $T = q\sqrt{D}$, in which T represents the time from the maximum or minimum in days, and D the difference in brightness in thousandths of a magnitude. The values of the factors q and q', before and after the maximum, are obtained from the nearest five consecutive observations; and the formula assumes that the portion of each quadrant of the light-curve, so far as used in the computation, varies inappreciably from a parabola, the foci of the two quadrants usually differing. With q and q' thus obtained, being the most exact determination the observations will afford, the time of the maximum is obtained from the nearest three consecutive observations; the nearest observation furnishing the approximate maximum brightness, and the time being interpolated between the other two. So far as practicable, errors of observation and temporary irregularities of the light-curve are smoothed out by successively interpolating, between the observations, points in new light-curves, applying a correction for curvature. Near the maximum this correction is subtracted, making the interpolated magnitudes brighter than the chord, and near the minimum it is added, making the interpolated magnitudes fainter than the chord. (See my memoir in *H. C. O. Annals*, XXIX, 124.)

The correction required in smoothing the curve is qt^2, t being one-half the interval. For a first approximation q may be taken from the following Table of Factors. If wholly unknown, q may be assumed to be 0.7. In observation it should be borne in mind that the smaller the value of q, the more frequent the observations must be in order to avoid appreciable inaccuracy in interpolation.

When the light-curve is observed only on one side of the maximum, or when the minimum is too faint for observation, an approximation can be obtained by the subtangent method, based upon the principle that the subtangent of a parabola is bisected at the vertex. From three consecutive smoothed observations on one side of the vertex, or from two consecutive observations on each side, two tangents can be obtained; and the two subtangents may be made to coincide at the vertex by an equation too simple to need explanation. Or, if the extreme brightness is known, this may be combined with a single tangent by a simple equation.

TABLE OF FACTORS FOR MAXIMA.

Star	Factors		Star	Factors		Star	Factors		Star	Factors		Star	Factors		Star	Factors	
103	0.67	0.93	1800	3.0	3.0	3264	0.59	0.63	5438	1.00	0.65	6900	1.22	1.36	7455	0.55	0.42
107	1.0	1.0	1803	2.1	2.0	3425	0.86	0.70	5494	0.94	0.91	6903	0.41	0.36	7458	0.90	1.10
112	0.90	0.50	1805	0.63	0.95	3477	0.30	0.38	5501	0.80	0.40	6905	0.30	0.36	7468	0.71	0.37
114	0.69	0.32	1923	1.6	1.6	3493	0.81	0.80	5511	0.83	0.64	6921	0.62	0.97	7560	0.69	0.52
434	2.1	2.1	1944	0.29	0.36	3567	0.18	0.54	5583	0.70	0.70	6923	0.35	0.35	7571	0.39	0.27
466	0.63	0.73	2100	0.66	0.63	3881	1.25	0.80	5617	0.50	0.70	7045	1.12	0.81	7577	1.10	0.65
513	0.51	0.48	2266	0.40	0.49	3994	0.45	0.58	5675	0.87	0.81	7085	0.69	0.68	7590	0.50	0.45
715	0.25	0.56	2478	1.42	0.86	4315	0.28	0.20	5677	0.84	0.85	7106	0.4	1.0	7659	0.59	0.47
782	0.72	1.18	2528	0.26	0.37	4407	0.57	0.44	5704	0.85	0.85	7118	0.37	0.37	7733	0.46	0.65
806	0.30	0.38	2539	1.05	1.28	4492	0.75	1.88	5761	0.14	0.14	7120	0.60	0.65	7909	0.47	0.61
845	0.19	0.28	2625	0.72	0.90	4596	0.60	1.00	5830	0.40	1.10	7155	0.51	0.71	8068	0.67	0.88
(857)	0.12	0.11	2684	1.29	1.23	4816	1.10	1.30	5831	0.78	0.78	7192	0.62	0.56	8153	1.2	1.2
893	0.38	0.39	2691	2.6	2.6	4847	0.41	0.53	5931	1.1	1.1	7220	1.3	1.4	8230	0.60	0.88
906	0.54	0.46	2742	0.70	0.50	4948	1.08	0.63	5950	0.87	0.81	7234	1.18	1.54	8373	0.70	0.48
976	2.	3.	2780	1.24	1.25	5037	1.64	1.33	6044	0.62	0.54	7242	1.00	1.20	8512	0.13	0.13
1113	1.31	1.53	2946	0.26	0.33	5070	0.82	0.82	6512	0.71	0.51	7252	0.45	0.44	8597	0.59	0.60
1222	0.90	1.10	2976	1.06	0.70	5174	0.77	0.42	6682	0.42	0.74	7260	0.53	0.62	8600	0.39	0.29
1577	0.80	0.67	3060	0.74	1.10	5194	1.13	1.24	6849	0.47	0.65	7261	0.60	0.61			
1582	0.67	0.36	3170	1.0	1.0	5237	0.57	0.61	6888	1.10	0.63	7431	0.55	0.62			
1717	0.46	0.68	3184	0.84	0.83	5338	0.94	1.28	6894	0.57	0.83	7444	0.40	0.70			

TABLE OF FACTORS FOR MINIMA.

Star	Factors		Star	Factors		Star	Factors		Star	Factors		Star	Factors		Star	Factors	
103	2.1	2.1	906	1.2	1.2	2735	1.30	0.70	5237	0.98	0.80	7045	2.0	1.1	8068	1.35	1.40
107	0.97	1.69	976	1.10	1.13	3186	1.6	1.5	5338	0.94	0.68	7085	0.76	0.79	8373	1.82	0.88
782	0.54	0.84	1222	1.35	1.35	3477	1.08	1.15	6207	0.73	0.88	7106	0.7	0.7	8512	0.60	0.70
806	1.6	1.6	1717	1.1	1.2	4160	0.45	0.60	6682	0.90	1.50	7120	1.8	1.3	8600	0.53	0.28
893	0.80	0.90	1771	1.5	2.1	5194	1.74	2.52	6849	1.10	0.70	7260	0.80	0.75			

In the following table, four additional columns have been introduced, showing for each observed maximum or minimum, first, the magnitude derived from the smoothed curves; then the two factors obtained from that curve; and finally, the interval of time in days included in the five observations from which the factors were obtained. The factors change materially for different intervals of time, especially when the intervals exceed ten days; and it will probably be found that there is a material change at different maxima for the same intervals. By comparison of these factors in different years, we may learn with increasing certainty the exact form of the crest of the light-curve, and its fluctuations.

In the table of Results of Observations, those derived from the observations of Mr. PERRY will hereafter be indicated, as his observations are indicated, by a small cap P, which will be placed in the column of weights. The weights are assigned in the same manner with my own, excepting that my own weights 5 to 9 indicate photometric observations, usually four extinctions of the variable upon each date, together with 6 to 16 extinctions of comparison-stars.

In the same table, dates which are derived from the elements, given for comparison with the observations, will be indicated by E in the column of weights.

RESULTS OF OBSERVATIONS.

No.	Star	Phase	Observed Date Julian	Observed Date Calendar	E	Corr.	W	Mag.	Factors			Remarks
				1896-7							d	
7502	*X Delphini*	Max.	3690 :	May	–	–	1	–	–	–	–	By subtangent method
"	"	Min.	3900 :	Dec.	–	–	1	–	–	–	–	Perhaps later
7560	*R Vulpeculae*	Max.	3871	Nov. 7	83	– 4	5P	–	–	–	–	
7577	*X Capricorni*	Max.	3888	Nov. 24	49	–	E	–	–	–	–	Observations interrupted
7590	*Z Capricorni*	Max.	3881	Nov. 17	1	–37	6	–	–	–	–	—7, from period *A.J.*372
7944	*T Pegasi*	Max.	3716	June 5	31	+ 2	3	–	–	–	–	
8230	*S Aquarii*	Max.	3807	Sept. 4	18	–13	2	–	–	–	–	Perhaps earlier
8290	*R Pegasi*	Max.	3787	Aug. 15	44	–22	4	–	–	–	–	Perhaps earlier
8369	*W Pegasi*	Min.	3977 :	Feb. 21	–	–	1	–	–	–	–	Subtangent approximation
8597	*V Ceti*	Max.	3858.6	Oct. 25	21	+ 4	9	–	–	–	–	
8622	*W Ceti*	Max.	3928	Jan. 3	1	–22	5	9.43	0.6	1.1	19	
103	*T Andromedae*	Min.	3877	Nov. 13	57	–	3	–	–	–	–	$M—m = 84$; from elements
"	"	Max.	3992	Mar. 8	57	+30	7	9.32	–	–	–	
134	*S Piscium*	Max.	3914 :	Dec. 20	28	–12	1P	–	–	–	–	Perhaps earlier
466	*U Piscium*	Max.	3950	Jan. 25	36	+10	7P	11.2	0.8	1.0	46	
513	*R Piscium*	Max.	3941	Jan. 16	32	+ 5	9P	7.37	0.70	0.77	35	
715	*S Arietis*	Max.	3912	Dec. 18	31	–13	1P	–	–	–	–	
782	*R Arietis*	Max.	3852	Oct. 19	59	– 4	5P	–	–	–	–	Light-curve fluctuates
"	"	Min.	3962 :	Feb. 6	60	+11	2	–	–	–	–	
806	*o Ceti*	Max.	3913.4	Dec. 19	33	+ 7	9	4.29	0.53	0.48	7	
"	"	Max.	3927	Jan. 2	33	+21	7P	–	–	–	–	
845	*R Ceti*	Max.	3890	Nov. 26	65	+ 7	9P	–	–	–	–	Nearly equal 3 weeks later
(857)	*— Ceti*	Max.	3856.5	Oct. 23	38	– 0.4	5	–	–	–	–	See note below
"	"	Max.	3874.3	Nov. 10	39	–	E	–	–	–	–	
"	"	Max.	3926.5	Jan. 1	42	–	E	–	–	–	–	
"	"	Max.	3961.3	Feb. 5	41	–	E	–	–	–	–	
893	*U Ceti*	Min.	3883	Nov. 19	19	+ 3	7	–	–	–	–	

(857) —*Ceti.* It was cloudy on the predicted date of each maximum during the season. The first observation confirms the period. Each third max. apparently about two days earlier than the elements, as heretofore; *A.J.* 377.

INDIVIDUAL OBSERVATIONS.

Including Observations by ARTHUR C. PERRY.

7502 *X Delphini.*

Julian	Calendar	Mag.
	1896	
3755.6	July 14	9.7
3787.6	Aug. 15	12.0
3809.6	Sept. 6	12.9
3860.5	Oct. 27	13.0]
3897.5	Dec. 3	13.0]
3924.5	30	12.0]

7560 *R Vulpeculae.*
(Continued from 372.)

Julian	Calendar	Mag.
	1896	
3797.5	Aug. 25	to
3814.6	Sept. 11	12.]P
	7 dates	

7560 *R Vulpec.*—Cont.

Julian	Calendar	Mag.
	1896	
3829.6	Sept. 26	10.8P
3833.5	30	10.7P
3857.6	Oct. 24	8.2P
3866.6	Nov. 2	8.1P
3870.5	6	8.2P
3900.5	Dec. 6	9.7P
3904.5	10	10.7P

7577 *X Capricorni.*
(Continued from 372.)

Julian	Calendar	Mag.
	1896	
3858.5	Oct. 25	12.0
3862.5	29	11.73_2

7577 *X Capric.*—Cont.

Julian	Calendar	Mag.
	1896	
3865.5	Nov. 1	11.51_2
3871.5	7	11.79_2
3888.5	24	11.33_2

7590 *Z Capricorni.*
(Cont from 372. Comp. Stars 372)

Julian	Calendar	Mag.
	1896	
3858.5	Oct. 25	10.3
3870.5	Nov. 6	9.49_2
3878.5	14	9.62_2
3880.5	16	9.23_2
3886.5	22	9.50_2

7590 *Z Capric.*—Cont.

Julian	Calendar	Mag.
	1896	
3891.5	Nov. 27	9.96_2
3895.5	Dec. 1	10.15_2

7944 *T Pegasi.*
(Continued from 339.)

Julian	Calendar	Mag.
	1896	
3711.7	May 31	9.6
3721.7	June 10	9.6
3730.7	19	9.8

8230 *S Aquarii.*
(Continued from 372.)

Julian	Calendar	Mag.
	1896	
3807.6	Sept. 4	7.68_2
3810.6	7	8.45_2

8230 *S Aquarii*—Cont.

Julian	Calendar	Mag.
	1896	
3813.6	Sept. 10	8.72_2
3813.7	10	8.4P
3819.6	16	8.17_2
3823.6	20	8.70_2

8290 *R Pegasi.*
(Continued from 346.)

Julian	Calendar	Mag.
	1896	
3777.6	Aug. 5	8.7
3786.6	14	8.7
3787.6	15	8.70_2
3789.6	17	8.73_2
3789.6	17	8.3P

8290 *R Pegasi*—Cont.

Julian	Calendar	Mag.
	1896	
3790.6	Aug. 18	8.72_2
3797.6	25	8.8P
3798.6	26	8.7P
3799.6	27	8.7P
3801.6	29	9.0P
3804.6	Sept. 1	9.2P
3807.6	4	9.88_2
3807.6	4	9.4P
3809.6	6	8.9P
3823.5	20	9.10

8369 *W Pegasi.*

Julian	Calendar	Mag.
	1896-7.	
3833.6	Sept. 30	9.0P
3848.7	Oct. 15	8.9P
3857.5	24	9.2P
3866.6	Nov. 2	9.4P
3870.5	6	9.7P
3890.5	26	9.9P
3905.5	Dec. 11	10.1P
3914.5	20	10.6P
3918.5	24	10.6P
3943.5	Jan. 18	10.7P
3948.5	23	10.9P
3956.5	31	12]
3975.5	Feb. 19	12]

8597 *V Ceti.*

(Continued from 346.)

Julian	Calendar	Mag.
	1896	
3814.6	Sept. 11	12.3
3829.6	26	10.21_2
3841.5	Oct. 8	9.75_2
3848.5	15	10.62_2
3854.5	21	9.94_2
3855.5	22	9.83_3
3857.5	24	9.84_2
3859.6	26	9.4P
3860.5	27	9.80_2
3862.6	29	9.7P
3864.5	31	9.97_2
3866.6	Nov. 2	10.2P
3870.5	6	10.34_2
3870.5	Nov. 6	10.4P
3888.5	24	11.63_2

8622 *W Ceti.*

(Continued from 372.)

Julian	Calendar	Mag.
	1896-7	
3922.5	Dec. 28	9.53_2
3924.5	30	9.57_2
3930.5	Jan. 5	9.32_2
3937.5	12	9.81_2
3943.5	18	9.49_2
3944.5	19	9.69_3
3950.5	25	9.72_2

103 *T Andromedae.*

(Continued from 377.)

Julian	Calendar	Mag.
	1896-7.	
3841.6	Oct. 8	13.1
3864.5	31	to
3918.5	Dec. 24	13.1]
	4 dates	
3930.5	Jan. 5	12.78_2
3948.5	23	12.29_2
3956.5	Jan. 31	11.7
3965.5	Feb. 9	11.0
3975.5	19	10.7
3983.5	27	10.26_2
3988.5	Mar. 4	9.13_2
3991.5	7	9.37_2
3994.5	10	9.33_2
3995.5	11	9.33
3996.5	12	9.4]
3997.5	13	9.61_2

434 *S Piscium.*

(Continued from 377.)

Julian	Calendar	Mag.
	1896-7	
3905.6	Dec. 11	10.2P
3914.5	20	9.8:P
3918.5	24	10.3P
3930.6	Jan. 5	10.4P
3948.5	23	10.7P

466 *U Piscium.*

(Continued from 377.)

Julian	Calendar	Mag.
	1896	
3905.6	Dec. 11	12.4]P
3918.6	24	12.4P
	1897	
3930.6	Jan. 5	12.4P
3948.5	23	11.3P
3956.5	31	11.2
3965.5	Feb. 9	11.6
3975.5	19	11.8

513 *R Piscium.*

(Continued from 377.)

Julian	Calendar	Mag.
	1896-7	
3859.6	Oct. 26	11.2P
3866.6	Nov. 2	11.9P
3890.6	26	11.0P
3897.7	Dec. 3	10.7P
3901.6	7	10.3P
3905.6	11	9.7P
3914.5	20	9.0P
3918.5	24	8.4P
3930.6	Jan. 5	7.4P
3943.5	18	7.5P
3948.5	23	7.5P
3957.5	Feb. 1	8.0
3963.5	7	8.1
3970.5	14	8.21_2

715 *S Arietis.*

(Continued from 314.)

Julian	Calendar	Mag.
3905.6	Dec. 11	10.7P
3918.6	24	10.7P
3930.6	Jan. 5	10.9P
3948.5	23	11.2P

782 *R Arietis.*

(Continued from 377.)

Julian	Calendar	Mag.
3841.6	Oct. 8	8.7P
3842.6	9	8.8P
3848.6	15	8.8P
3857.5	24	8.5P
3862.6	29	9.0P
3866.6	Nov. 2	8.8P
3870.6	6	8.7P
3886.5	22	9.2P
3890.6	26	9.3P
3897.7	Dec. 3	9.9P
3943.5	Jan. 18	10.4]P
3948.6	Jan. 23	12.0P
3960.5	Feb. 4	13.1]
3975.5	19	13.4
3983.5	27	12.1

806 *o Ceti.*

(Cont. from 377. Comp. Stars 377)

Julian	Calendar	Mag.
3841.7	Oct. 8	8.5P
3842.6	9	8.6P
3848.6	15	8.4P
3857.6	24	7.8P
3859.6	26	7.7P
3862.7	29	7.5P
3866.7	Nov. 2	7.1P
3870.6	6	6.9P
3886.5	22	5.5P
3890.6	26	5.4P
3901.5	Dec. 7	4.54_2
3904.5	10	4.67_2
3904.5	10	4.7P
3905.6	11	3.92_2
3905.6	11	4.3P
3907.5	13	4.71_2;
3908.5	14	4.39_2;
3911.5	17	4.14_2
3913.4	19	4.40;
3914.4	20	4.33_2
3915.4	21	4.15_2
3918.6	24	4.0P
3919.5	25	4.54_2
3921.5	27	4.82_2
3925.5	31	5.20_2:
3930.6	Jan. 5	4.2P
3943.5	18	4.1P
3948.5	23	4.2P

845 *R Ceti.*

(Continued from 377.)

Julian	Calendar	Mag.
3842.7	Oct. 9	11]P
3848.6	15	11]P
3857.5	24	11]P
3859.5	26	11P
3862.6	29	10.7P
3866.6	Nov. 2	10.5P
3870.6	6	9.9P
3886.5	22	9.0P
3890.6	26	9.4P
3897.6	Dec. 3	8.5P
3899.5	5	8.6P
3901.7	7	8.9P
3904.6	10	8.8P
3905.6	11	8.8P
3914.5	20	8.7P
3918.6	24	8.9P
3930.6	Jan. 5	10.0P
3943.6	18	10.7P
3948.5	23	11.4P

(857)—*Ceti.*

(Cont. from 377. Comp. Stars 377)

Julian	Calendar	Mag.
3852.5	Oct. 19	9.13_2
3854.5	21	9.17_2
3854.6	21	10.04_2
3855.6	22	8.66_3
3857.5	24	8.73_3
3857.6	24	8.73_3
3858.6	25	9.36_2
3870.5	Nov. 6	9.26_3
3871.5	7	9.04_3
3873.5	9	9.08_3
3922.5	Dec. 28	9.11_3
3924.5	30	8.91_2
3925.5	31	9.25_3
3957.5	Feb. 1	8.83_3;
3960.5	4	8.88_3

893 *U Ceti.*

(Cont. from 377. Comp. Stars 346)

Julian	Calendar	Mag.
3842.6	Oct. 9	10.4
3870.6	Nov. 6	12.4
3871.6	7	12.62_2
3888.5	24	12.8
3897.6	Dec. 3	12.2]
3918.5	24	11.08_2
3921.5	27	10.72
3925.5	31	10.76_2
3930.5	Jan. 5	10.13_2

ON NYRÉN'S VERTICAL-CIRCLE OBSERVATIONS, 1882–91,

By S. C. CHANDLER.

In a note with the above title I took the liberty three years ago (*A.J.* XIV, 13) to suggest that, to secure the full fruits of this admirable series of observations as regards the question of the variation of latitude, a discussion of them was desirable with the view to ascertain whether, in addition to the 428-day term for which Mr. NYRÉN had already used them so effectively (See *A.N.* 3166 and *Bull. de l'Acad. de St. Pétersbourg*, 1893), they would manifest the presence also of the annual term of this variation. It was not to be expected indeed, from the nature of the material, that the full effect of this term would be exhibited; but it was reasonable to anticipate that at any rate the latter portion of the series, from 1887 to 1891, would give, when properly discussed, qualitative if not quantitative evidence of considerable value on this subject.

Such an examination has now in fact been made by NYRÉN in the introduction to Volume II, Series II, of the Publications of the Pulkowa Observatory, just received. This I have read with very great surprise because his conclusions are exactly opposite to those which I had already drawn from the same facts, but had refrained from publishing in order to avoid the apparent discourtesy of anticipating the distinguished author of these magnificent and laborious instrumental researches. Even now I should be inclined to withhold my own investigation, from unwillingness to appear disputatious, did not the question touch a point in which fundamental astronomy is vitally interested, namely the correctness of the new Pulkowa declinations. For, if I am not mistaken, the correction which Nyrén has applied for variation of latitude leaves his declinations affected by a term varying with the right-ascensions, having a coefficient of nearly 0″.15. A systematic error of this sort cannot be neglected in the present condition of the astronomy of precision.

To save repetition I shall ask the reader to examine, in either of the places above cited, the nature of the material on which the investigation is made, and the manner in which Nyrén has deduced his mean curve and the table of corrections therefrom derived. So far there can be no criticism. In order now to understand the objection which I deem it legitimate to raise to his further processes and conclusions, I would direct attention to the following paragraph from the new Pulkowa volume, p. (39). "Il a déjà été indiqué plus haut pourquoi la question s'il existe ou non dans le mouvement du pôle terrestre aussi une période annuelle ne peut être tranchée avec sûreté par la série actuelle. Cependant, les observations de chaque étoile isolée s'étendant en moyenne sur un intervalle de deux mois, on devait attendre de trouver dans une série si étendue, si non les valeurs numériques des amplitudes, du moins des traces de la période. Pour me convaincre s'il en était ainsi, j'ai utilisé les différences $L_i - L_m$ données dans le tableau pp. (32)–(37) une fois sans tenir compte de la période de 14 mois, l'autre fois en y appliquant les corrections exigées par la courbe de la planche ci-après. Il en résulta les moyennes suivantes ;" — In the table which here follows we are concerned only with the column "Corrigé pour la période de 14 mois." With regard to this column the author says: — "Si la période de 14 mois est réelle et, en même temps, si les corrections empruntées à la courbe mentionnée correspondent en grandeur aux variations de la latitude, les résidus que nous montre la seconde série du tableau sont si insignifiants et leurs signes se présentent d' une marche si irrégulière qu'on serait tenté de nier l'existence de toute autre période. On peut, du moins, prétendre que s'il existe une période annuelle, l'amplitude de ses oscillations doit être trop faible pour qu'on puisse en découvrir des traces distinctes dans la série discutée ici." He then adds: "Cette dernière conclusion est difficile à concilier avec les formules empiriques de M. Chandler." To this I in turn feel constrained to add that this conclusion is equally difficult to reconcile with the facts when correctly construed, for it seems to me that the meaning of the column in question is here entirely misconceived, and that the process of deriving it for the purpose of detecting the presence of an annual term in the latitude is pure reasoning in a circle. Indeed the heading of the column is a misnomer since the corrections applied are not those for a 14-months' term, as they purport to be, but the readings from a curve which comprises not only this term but also all traces of the annual term which the observations are competent, from their nature, to show. The final column of residuals, from which the non-existence of an annual term is inferred, are and ought to be nearly zero, and would be precisely zero if the observations were exactly correct and the curve drawn with absolute accuracy. In other words, all evidence which these observations are competent to show of an annual term are contained in the curve itself and not in the difference between this curve and the observations. Therefore the conclusion above cited seems to me to be a fallacy, the kind of hasty inadvertence into which even the clearest mind is liable to fall, and which, I feel sure, will be recognized as such by its author.

Now to see, by a correct method, what evidence is really furnished by these observations of an annual term, let us take this curve, or what is the same thing the corrections on pp. (40) to (43) of the introduction to the Pulkowa volume, and subtract the 14-months' term, using the coefficients given by eq. (52), *A.J.* XIV, 74. Arranging the resulting differences in order of time, τ, from the beginning of the year, and taking the means for all, and also for the two intervals 1882–87 and 1888–91, we have the following table:

τ	1882–91	1882–87	1888–91
	″	″	″
0.00	−0.026	−0.008	−0.052
.05	− .033	− .005	− .075
.10	− .040	− .008	− .087
.15	− .043	− .005	− .100
.20	− .044	.000	− .100
.25	− .040	+ .001	− .102
.30	− .029	+ .005	− .080
.35	− .026	+ .007	− .072
.40	− .014	+ .012	− .052
.45	− .008	+ .013	− .040
.50	+ .004	+ .017	− .015
.55	+ .016	+ .018	+ .010
.60	+ .022	+ .017	+ .030
.65	+ .019	+ .015	+ .030
.70	+ .030	+ .020	+ .060
.75	+ .046	+ .015	+ .107
.80	+ .048	+ .013	+ .100
.85	+ .045	+ .008	+ .100
.90	+ .032	− .003	+ .085
0.95	−0.014	−0.012	−0.017

Now, as explained by Nyrén, the observations for the catalogue are comprised between 1882 and 1887, during which interval the individual stars were observed largely at the same season of the year in the different years, and consequently the effect of an annual term would be masked. After 1887 the observations relate almost exclusively to polar and bright stars which could be observed in different seasons. On account of this more extended distribution from 1888 to 1891, the mean values of the declinations are nearly free from any effect of variation of latitude; hence the residuals shown by the separate observations should represent the latitude-variation quite correctly. Our table above fully bears out this interpretation.

From the last column of the table we obtain,

$$(a)\qquad -0''.013\ -0''.094\cos(\odot-8^\circ)$$

where the coefficient 0″.094 may be regarded as a minimum-value of the coefficient of the annual term, as shown by the only portion of the series which is adapted to betray certainly its existence. From eq. (52) we have, referred to the Pulkowa meridian,

$$(b)\qquad -0''.142\cos(\odot-3^\circ)$$

and similarly from eq. (57), *A.J.* XIV, 129,

$$(c)\qquad -0''.146\cos(\odot-11^\circ)$$

A comparison of (*a*), (*b*) and (*c*) will obviate the necessity for carrying the demonstration further.

To return to the important question of the sufficiency of the corrections applied by Nyrén to the observed declinations to free his catalogue from the latitude-variation, it will be seen from the column 1882–87 of the above table, that the corrections on pp. (40)–(43) of his introduction to vol. II contain, *for this interval*, practically merely the effect of the 428-day term. His catalogue then must still be affected by a term varying with the right-ascension, having a coefficient of nearly 0″.15, as stated near the beginning of this article. To get a general idea of it, if we assume the average mean time of his observations to be $8^h\ 30^m$, we have approximately the systematic correction needed by the new Pulkowa declinations, as they stand,

$$+0''.14\sin(\alpha+135^\circ)\qquad (d)$$

For the corresponding correction of the Pulkowa 1865 catalogue, I found four years ago (*A.J.* XIII, 63),

$$+0''.09\sin(\alpha+153^\circ)\qquad (e)$$

And it may be noted that the Berlin observations for latitude, through Küstner's catalogue of 1890, which is differentially referred to the *Fundamental-Catalog*, have recently (*V.J.S.*, 1896, p. 104) led to the similar correction

$$+0''.12\sin(\alpha+120^\circ)\qquad (f)$$

The last result possesses merely a moderate interest, as a sort of indirect confirmation of the true correction (*e*), which was deduced directly from the vertical-circle observations of 1863–75.

With the foregoing demonstration this article might end. But a word of comment seems appropriate upon a remark following the last quotation. "Mais sans vouloir, en conséquence de ces résultats, nier l'existence d'une période annuelle dans la latitude, il me parait justifié d'en exiger des preuves plus concluantes que celles qu'on a données jusqu'a présent." This bears date of June, 1895. If it is not too great presumption to assume that Mr. Nyrén had read attentively the proof which I had printed to that time, I can only remark, as to this expression of opinion, that it is beyond my power to furnish any that is more conclusive. If he has examined by correct methods all the evidence that has been presented, and is still unsatisfied, I can only admire the conservatism that is implied, while regretting that it has stood in the way of the eradication from his declinations of the systematic error above indicated.

NOTE ON *U GEMINORUM*,

BY REV. J. G. HAGEN.

The publication of two maxima of *U Geminorum* in *A.J.* 393 and 399, by Mr. Sperra, induces me to send you my observation of the last maximum, which I fortunately obtained while making my chart for this variable. The star was invisible in our 12-inch refractor on February 28 and March 26, 1897, but was nearly stationary at $9^M.0$ on March 3, 7 and 10. On March 12 its brightness was on the decline. It may be of interest to have these three maxima put together with the smallest residuals resulting from the different epochs of Chandler's Catalogues, which represent the last maxima observed at the time. These residuals give an idea of the curious irregularities of this unique variable.

The three Catalogues give the following elements for the purpose of approximate prediction :

Max.:

(I, 1879 Oct. 24; II, 1892 Dec. 15; III, 1895 Oct. 28) $+86^d.3$ E.

Obs.	Observed Max.	I	II	III
Sp.	1896 Mar. 17.2	$69\,E+34^d$	$14\,E-20^d$	$2\,E-31^d$
Sp.	1896 Dec. 1.5	$72\,E+35$	$17\,E-20$	$5\,E-31$
H.	1897 Mar. 7 ±	$73\,E+44$	$18\,E-10$	$6\,E-22$

Counting from the last maximum, the next is due in the beginning of June and cannot be observed.

Georgetown College Observatory, Washington, D.C., 1897 *April* 1.

REVISED ELEMENTS OF 5190 *R CAMELOPARDALIS*,

BY S. C. CHANDLER.

Observations within a few years appear to make certain, what I had previously suspected, that the period of this star has been slowly lengthening since its discovery in 1858, from about $265^{\rm d}$ to nearly $275^{\rm d}$ at the present time, at the average rate of about $0^{\rm d}.16$ from maximum to maximum. Therefore, for the elements given in the Third Catalogue, the following may be substituted with advantage:

$$1869 \text{ Sept. } 2\ (2403943) + 267^{\rm d}.5\,E + 0^{\rm d}.08\,E^2$$

The individual phases are subject also to considerable irregularities.

NOTE ON THE VARIABLE STAR 7792 *SS CYGNI*,

BY PAUL S. YENDELL.

Since the publication, in *A. J.* 395 and 397, of J. A. PARKHURST's and my own observations of *SS Cygni*, the star has been under observation by Mr. SPERRA, who writes me, under date of March 30, sufficient particulars of his work to entirely confirm my suspicion that the star's variation is identical in type with that of *U Geminorum*.

Mr. SPERRA's observations show that the star continued constant at its normal brightness, of about $11^{\rm M}.3$, through February and until the morning of March 19. On the latter date he observed it as $11^{\rm M}.0$, and on the morning of March 21 as $7^{\rm M}.7$. Since the latter observation the star has decreased very rapidly, and at the date of Mr. SPERRA's letter had returned to nearly its normal faintness. These observations confine the duration of the increase to two days, and also, taken in connection with the observations published by PARKHURST and myself, indicate that the light-curve is not constant at different maxima. The proof of the type of variation is unequivocal.

The interval between these two maxima is a little over sixty days, as SPERRA's observations seem to shut out the possibility of any intervening maximum.

Dorchester, Mass., 1897 *April* 2.

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CORRIGENDUM.

No. 398, p. 108, line 9, in heading of table, *for* φ_0 *put* φ.

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THE ASTRONOMICAL JOURNAL.
CORRIGENDUM.

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THE VARIATION OF LATITUDE AT NEW YORK, AND A DETERMINATION OF THE CONSTANT OF ABERRATION FROM OBSERVATIONS AT THE OBSERVATORY OF COLUMBIA UNIVERSITY,

By JOHN K. REES, HAROLD JACOBY AND HERMAN S. DAVIS.

The results described below were obtained from observations of 1774 pairs of stars made between 1893 May 6 and 1894 June 20 with an 8-centimetre Wannschaff zenith-telescope. The observations were planned for a determination of the constant of aberration by KÜSTNER's method. Four groups of stars were used, having mean right-ascensions approximately as follows:

Group	I	6^h
	II	14
	III	18
	IV	22

Each group contained seven pairs of stars, and the groups were observed both morning and evening, whenever the weather permitted. The original plan of observation required four observers, but it was unfortunately necessary to reject altogether the work of one observer. This has of course caused considerable gaps in the series, in addition to those due to unfavorable weather conditions.

The following table contains the latitude-results employed for the computation of the constant of aberration. For this purpose, we used only observations obtained during the periods when it was possible to observe evening and morning groups. The observations of each group were gathered together into periods of about ten days each, in such a manner that the weighted mean of the dates is nearly the same for both the evening and morning groups. In this way, the mean latitudes from the two groups should differ only on account of the difference between the declination-systems of the two groups, and on account of any error in the assumed value of the aberration-constant. They cannot differ on account of variation of latitude, provided we assume that any such variation is uniform during the short time of ten days. Our result for the aberration-constant is therefore independent of any assumption as to the law of latitude-variation.

The weights given in the second and seventh columns are equal to the number of pairs observed, except that whenever a complete set of seven pairs was obtained, the weight was increased to 8.

The aberration-factors in the table have the following meaning:

If we put

C = the number 20.4451
ΔC = correction to the constant 20″.4451
$x = \frac{\Delta C}{C}$

then if x were $+1''$, all the latitudes in the table would be larger by a number of seconds equal to the aberration-factors set down next to the latitudes.

Combining the results in the table we get the following mean values for the differences of the latitudes from the successive groups, together with the effect upon them of any error in the aberration-constant. The quantities given for groups II–III, are the means of the results obtained in 1893 and 1894. We note that the numbers from the two years agree exactly in the mean, though this is of course accidental.

Group	II–III	$+0''.132$	$+11.9x$	wt. 206
	III–IV	$-\ .038$	$+12.2$	44
	IV–I	$-\ .111$	$+18.9$	53
	I–II	-0.018	$+19.2$	97

The sum of these four quantities may be equated to 0, since the errors of the declination-systems of the several groups will not affect the cyclical sum of the differences. In this way we obtain,

$$-0''.035 + 62.2\,x = 0 \qquad \text{wt. } 18$$

The correction required by the constant of aberration is therefore,

$$+0''.0115$$

and the constant itself,

$$20''.4566$$

The probable error of a single latitude was found, from the residuals obtained in the comparison of the mean latitude on any night with the several constituent latitudes, to be,

Probable error of a single latitude = ±0″.16

Consequently the probable error corresponding to the weight of the above constant of aberration is ±0″.013, and we have finally, as the result of the present research,

Constant of Aberration = **20″.457** ±0″.013

The value of *x* having been obtained, we can correct the above group differences, and obtain the corrections necessary to reduce the declination-system of each group to the mean of all. These corrections are found to be,

Group I	−0″.056
II	− .063
III	+ .075
IV	+0.044

These numbers are very small, but they indicate a slight dependence of Auwers's declination-system upon right-ascension.

Determination of the Constant of Aberration.

(Latitude = 40° 48′ + seconds in Table.)

Group	Wt.	Weighted Mean			Group	Wt.	Weighted Mean			Groups	Difference		Wt.
		Date	Lat.	Aberr. Factors			Date	Lat.	Aberr. Factors		Lat.	Aberr. Factors	
II	47	'93 May 9	27″.212	+ 1.1	III	44	'93 May 9	27″.225	−11.7	II–III	−0″.013	+12.8	23
II	30	May 22	.261	+ 4.4	III	39	May 21	.107	− 8.7		+ .154	13.1	17
II	39	June 5	.263	+ 7.9	III	51	June 7	.078	− 4.3		+ .185	12.2	22
II	22	June 19	.345	+10.3	III	31	June 19	.074	− 0.4		+ .271	10.7	13
										Means	+0.132	12.3	
III	23	July 9	27.175	+ 5.5	IV	20	July 10	27.169	− 7.0	III–IV	+0.006	12.5	11
III	40	July 22	.060	+ 8.3	IV	40	July 23	.142	− 3.7		− .082	12.0	20
III	32	Aug. 5	26.965	+11.5	IV	21	Aug. 7	26.973	+ 0.9		− .008	12.4	13
										Means	−0.038	12.2	
IV	26	Oct. 15	27.192	+15.2	I	21	Oct. 14	27.300	− 4.8	IV–I	−0.108	20.0	12
IV	28	Oct. 30	.145	+16.2	I	25	Oct. 30	.328	− 4.0		− .183	20.2	13
IV	18	Nov. 9	26.978	+16.1	I	27	Nov. 9	.201	− 3.3		− .223	19.4	11
IV	31	Nov. 21	27.192	+15.5	I	25	Nov. 21	.180	− 2.0		+ .012	17.5	14
IV	4	Dec. 6	.340	+14.0	I	27	Dec. 7	.316	− 0.2		+ .024	14.2	3
										Means	−0.111	18.9	
I	46	'94 Jan. 12	27.302	+ 2.7	II	38	'94 Jan. 13	27.252	−14.6	I–II	+0.050	17.3	21
I	48	Jan. 29	.195	+ 4.0	II	25	Jan. 28	.258	−15.5		− .063	19.5	16
I	46	Feb. 11	.217	+ 4.8	II	27	Feb. 10	.270	−15.4		− .053	20.2	17
I	39	Feb. 23	.201	+ 5.4	II	39	Feb. 23	.249	−14.6		− .048	20.0	20
I	42	Mar. 4	.314	+ 5.6	II	51	Mar. 4	.311	−13.6		+ .003	19.2	23
										Means	−0.018	19.2	
II	46	Apr. 12	27.248	− 5.9	III	37	Apr. 12	27.176	−15.8	II–III	+0.072	9.9	21
II	45	Apr. 25	.244	− 2.6	III	46	Apr. 25	.131	−14.3		+ .113	11.7	23
II	48	May 2	.274	− 0.7	III	38	May 2	.049	−13.1		+ .225	12.4	21
II	43	May 12	.313	+ 1.8	III	32	May 12	.080	−10.7		+ .233	12.5	18
II	47	June 1	.169	+ 6.9	III	14	June 1	.131	− 5.6		+ .038	12.5	23
II	42	June 13	.215	+ 9.2	III	64	June 15	.087	− 1.9		+ .128	11.1	25
										Means	+0.131	11.7	

Observations have been continued from the date last given to the present time by Professor Rees and Dr. Davis, and will be kept up for some time longer. Reductions of the later series will be finished soon. A series of observations on the same stars has been made and is now being continued at the Royal Observatory at Capodimonte, Naples, by Professor Em. Fergola and two assistants, Messrs. Contarino and Angelitti. The following table contains the final mean latitudes, corrected for the error of the constant of aberration, as found above, and for the reduction of each group to the mean of all. A mean value is given for each ten days of observation, together with the weighted mean date to which the mean latitude belongs.

DEFINITIVE LATITUDES.

	φ 40° 48′+	$\varphi-\varphi_0$	Weight
1893 May 9	27.222″	+0.027″	86
19	.144	− .051	48
27	.162	− .033	45
June 8	.178	− .017	66
17	.198	+ .003	46
28	.259	+ .064	36
July 8	.262	+ .067	32
19	.177	− .018	43
26	.141	− .054	52
Aug. 6	.029	− .166	49
Oct. 6	.377	+ .182	34
15	.244	+ .049	47
30	.241	+ .046	49
Nov. 9	.111	− .084	49
20	.204	+ .009	51
Dec. 3	.232	+ .037	18
11	.255	+ .060	31
23	27.302	+0.107	45
1894 Jan. 2	27.192″	−0.003″	39
11	.168	− .027	90
23	.198	+ .003	68
Feb. 2	.214	+ .019	63
12	.148	− .047	65
24	.193	− .002	93
Mar. 5	.234	+ .039	72
21	.083	− .112	56
Apr. 1	.192	− .003	36
11	.199	+ .004	69
23	.218	+ .023	92
May 2	.153	− .042	99
12	.225	+ .030	69
29	.216	+ .021	55
June 8	.079	− .116	73
17	27.193	−0.002	69
Mean	27.195		

Columbia University Observatory, 1897 *April* 14.

OBSERVATIONS OF COMET 1896 VII,

COMMUNICATED BY F. P. LEAVENWORTH.

1896 Northfield M.T.	*	No. Comp.	☄ − * $\Delta\alpha$	☄ − * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
Dec. 28 7ʰ 52ᵐ 56ˢ	1	. .	+3ᵐ 4.25ˢ	+32′ 51.9″	2ʰ 59ᵐ 55.63ˢ	+0° 13′ 52.4″	*n*8.803	0.886
7 52 56	2	. .	+2 34.71	−12 48.4	2 59 56.19	+0 13 52.4	*n*8.803	0.886
7 52 56	3	. .	−0 2.79	−13 25.7	2 59 55.68	+0 13 53.2	*n*8.803	0.886
7 52 56	4	. .	−2 56.67	+19 34.1	2 59 56.28	+0 13 52.5	*n*8.803	0.886

Mean Places for 1896.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	2ʰ 56ᵐ 46.80ˢ	+4.58ˢ	−0° 19′ 20.3″	+20.8″	Munich I, 1032
2	2 57 16.89	+4.59	+0 26 19.8	+21.0	Schjellerup 858
3	2 59 53.86	+4.61	+0 26 58.1	+20.8	Schjellerup 869
4	3 2 48.34	+4.61	−0 6 2.1	+20.5	Munich II, 640

The above positions were obtained from a photograph of the comet taken by Dr. H. C. WILSON, at Goodsell Observatory. The time of exposure was from 7ʰ 13ᵐ 24ˢ to 8ʰ 32ᵐ 24ˢ Northfield M.T. The measurements were made with the Repsold photographic measuring machine of the University of Minnesota. Both measurements and reductions were made by ROY Y. FERNER and PAUL G. SCHMIDT, students of the University of Minnesota. The middle time of exposure was taken as the time of observation, and the measurements were made from the ends of the star trails.

Minneapolis, 1897 *April* 13.

MICROMETRIC MEASURES OF THE SATELLITE OF *NEPTUNE*,

MADE WITH THE 24-INCH REFRACTOR OF THE LOWELL OBSERVATORY,

BY D. A. DREW.

The following measures of the satellite of *Neptune* were made by Mr. COGSHALL and myself with the 24-inch refractor and Clark-micrometer of the Lowell Observatory.

The measures were begun on 1896 Oct. 16, and continued to March 27 following, with an interruption of about two months while the observatory was being moved from Flagstaff to the City of Mexico.

In all of the work a power of 500 was used, with the exception of the measures of Oct. 16, which were made with a power of 750. Wires illuminated with a red light were always used, but generally on moonlight nights, and during bad seeing, the illumination was faint. In all but one instance the position-angles were taken first, and then the wires were set at an angle differing by 90° from the mean of the position-angles and the distance measured. The position-angles were generally taken by placing both planet and satellite between the micrometer-wires, but at times it was found more advantageous to place the wires in coincidence and pass them over the centers of both disks. The distances were measured, as nearly as could be judged, between the centers of both disks.

Since in Flagstaff Standard Mountain Time was used, and in Mexico the local time of the National Observatory, it has been thought best to reduce the time of observation to that of some one place, and to give it in hours and fractions of an hour. Accordingly Greenwich Mean Time has been chosen.

In the various columns of the table below will be found the date, the Greenwich Mean Time T of the observation, the position-angle P.A. of the satellite, the distance D of the same, and the number N of the measures. In all the measures of distance, N indicates the number of double distances, except for Feb. 23, when but one measure was made, and on but one side of the fixed wire.

In every case the mean of the measures is given, and the mean of the times of observation.

Date	T	P.A.	D	N	Remarks
1896	h		″		
Oct. 16	20.1542	99.7		4	Seeing good
	20.6278		13.75	3	
Oct. 19	20.0333	280.0		3	Seeing good
	20.2056		11.17	3	
Oct. 29	20.2917	52.0		2	Cloudy; seeing poor
	20.4056		15.18	3	
Oct. 30	19.7750	338.4		2	Seeing good
	20.0656		10.25	3	
Nov. 4	20.2750	41.1		2	Seeing good
	20.6694		14.22	3	
Nov. 6	19.8333	263.0		4	Seeing poor, unsteady
	20.3067		15.71	4	
Nov. 7	19.8833	222.4		3	Seeing poor
	20.3542		14.21	4	
1897 Jan. 6	15.6963	132.3	. .	5	Hazy; poor seeing
Jan. 7	15.8338	77.7	. .	4	Seeing poor
Jan. 8	15.4504	38.4	. .	4	Satellite very faint
Jan. 9	18.7629	298.3		4	Seeing good
	19.1629		11.39	3	
Jan. 11	17.8796	209.7		5	Moonlight; satellite very faint; seeing poor
	18.1824		11.69	3	
Jan. 14	17.9996	20.2		5	Moonlight; seeing good
	18.6479		11.73	5	
Jan. 18	18.1796	108.5		3	Moonlight; hazy; seeing poor
	18.7088		12.45	4	
Jan. 28	18.4713	234.7		6	Seeing poor
	19.1863		16.04	4	
Jan. 30	18.1796	94.9		6	Seeing very poor
	18.5796		14.85	4	
Feb. 1	18.9629	316.3	. .	4	Clock running badly
Feb. 6	16.6324	53.5		6	Satellite very faint; seeing poor
	16.9713		15.73	4	
Feb. 8	17.9985	264.5		8	Seeing fair
	18.5129		15.16	5	
Feb. 13	17.7379	326.2		6	Moonlight; satellite faint
	18.4246		10.25	5	
Feb. 18	17.2852	40.7		6	Moonlight; hazy; satellite very faint
	17.6713		14.32	4	
Feb. 19	17.2462	316.6		3	Moonlight; driving clock running badly
	17.8962		9.91	2	
Feb. 20	17.4029	256.9		5	Moonlight; seeing fair
	17.7529		15.54	5	
1897 Feb. 21	16.4713	216.3		6	Satellite faint
	16.9588		13.52	4	
Feb. 22	16.8963	133.5		6	Seeing fair, unsteady
	17.4179		10.87	5	
Feb. 23	16.2296	75.7		6	Clock running badly; wires catching
	16.8296		16.34	1	
Feb. 24	16.1352	34.8		6	Seeing fair, unsteady
	16.6213		13.32	4	
Feb. 25	15.0018	312.4		9	Seeing fair, unsteady
	15.4629		10.27	4	
Feb. 27	16.7407	210.4		6	Seeing good; satellite very faint
	17.0213		12.87	4	
Feb. 28	15.5296	128.1		6	Seeing good
	15.8963		10.84	5	
Mar. 1	15.4796	73.7		6	Seeing good
	16.0046		16.70	5	
Mar. 2	15.5153	29.2		7	Satellite very faint
	15.9088		13.05	6	
Mar. 3	14.2768	302.0		6	Satellite faint
	14.7081		11.47	6	
Mar. 4	14.1740	253.2		6	Seeing good
	14.5088		15.97	6	
Mar. 6	14.1254	122.7		8	Satellite faint; strong wind blowing
	14.5865		11.27	6	
Mar. 7	14.2713	73.0		6	Seeing good
	14.7032		15.90	6	
Mar. 8	14.1629	24.5		6	Moonlight; seeing good
	14.5914		12.44	6	
Mar. 9	14.2924	299.4		8	Moonlight; hazy; satellite very faint
	14.7226		11.31	6	
Mar. 10	13.9536	250.5		8	Moonlight; hazy; satellite very faint
	14.4129		16.32	6	
Mar. 11	14.0296	202.9		8	Moonlight; seeing poor; wires catching
	14.3685		11.84	6	
Mar. 12	14.1046	113.7		8	Moonlight; cloudy; strong breeze
	14.4768		12.51	6	
Mar. 19	13.6213	65.4		6	Hazy; seeing poor
	13.9296		16.67	6	
Mar. 25	13.8213	60.1		6	Hazy; seeing poor; wires catching
	13.9963		16.72	5	
Mar. 26	14.0344	354.9		7	Wind swaying telescope; wires catching
	14.2963		10.00	6	
Mar. 27	14.5879	275.5		6	Hazy; strong breeze blowing
	14.9865		13.42	6	

Lowell Observatory, 1897 *March* 30.

DIVISION-CORRECTION OF THE CIRCLES OF THE MERIDIAN INSTRUMENT AT ALBANY,

By LEWIS BOSS.

What is offered here is in continuation of the paper under a similar title published in nos. 382 and 383 of the *Astronomical Journal*, and is based on extensive additional material of observation. The only possible excuse for presenting another communication here upon this subject would be that further deductions of general interest to practical astronomy have been made, or that the former ones have been placed in a new and stronger light.

There seems to be no occasion to enter further upon the elucidation or merits of the new method employed in this investigation. But there would be undoubted general interest in finding out what precision in graduating circles has actually been reached; for contributions of exact knowledge upon this point are still scanty. Are systematic errors of graduation measureable and relatively important? Since it is generally regarded as impracticable to determine the errors of all the lines, does it pay to go through all the labor of an attempt to determine from a limited number of lines those errors of graduation which may properly be termed systematic? This question is of course merely a modification of the first question. Growing out of it arises the question: what is the probable magnitude of casual errors of graduation, and how accurate must be the determination of errors in order to secure a really useful result? This last question is the *crux* of the entire subject.

To make adopted systematic corrections really satisfactory there must be some reasonably plausible assumption as to their origin. If the probable law of the correction can be prescribed, the result may be reached with much greater confidence as well as facility. For example, at one stage of the present investigation, the corrections for each degree were ascertained. There might have been a temptation to stop here and to construct a curve of adopted corrections in the usual manner and without any assumption as to its nature. But this course would have led to egregious residual errors of a systematic nature and of almost as much importance as those which would have been corrected. Even a casual inspection of the table of corrections (*A.J.* 383, p. 197) is sufficient to show that account must be taken of the fact that for the Olcott Circle (and presumably for all circles by Pistor and Martins) the curve of correction may be markedly discontinuous at the beginning of a degree, and especially so at multiples of 5°. This is obvious at 15°, 25° and 75°, when the subdivisions of the degree are taken into account, — the further research upon all the lines at 10′, 30′ and 50′ having greatly intensified this evidence of discontinuity. This arises largely from the fact that there is a virtually systematic difference of about $0''.3$ between the corrections for the first third and the last third of the degree-subdivisions.

These two facts are of primary importance in deciding upon a scheme of systematic corrections for these circles. A knowledge and appreciation of them in the beginning would have resulted in a great saving of labor in this investigation. Where it has been found that observations afford more consistent results when not corrected for the deduced errors of graduation, as at Munich and Berlin, this is more likely to be due to the peculiarities of the systematic corrections required, rather than to inaccuracy in the deduction of corrections for the few lines which have been investigated.

Soon after the publication of the former paper (*A.J.* 382–3) of which this is a continuation, or appendix, this investigation was extended to every 10′ of both circles by methods already described. The number of series was only eight, however, and each set of readings for the comparison of the circles at intervals of 10′ extended over a full degree, seven settings advancing, and seven more on the return, — the limiting 0′ graduations on Circle A being both included. Thus additional constant errors in the determination of the new lines are almost wholly avoided. The entire work upon the 10′ arcs cost about 350 hours of observing for two persons, and nearly as much more of computing. Each correction for a setting (mean of four lines in the four quadrants) required in all about two and one-half hours of the labor of one person for its ascertainment. There have now been determined in the entire work the actual corrections for 1080 settings, representing 4320 graduation-lines, exclusive of the known corrections in the arc 37° 20′ to 42° 0′ with its corresponding quadrants. In the work upon 10′ arcs, Circle A was read by Assistants Roy and Varnum, and Circle B by me; the computations were mostly by Mr. Varnum. The probable error of the final determination of the corrections for 10′, 30′ and 50′ is $\pm 0''.042$, ascertained in the same way as were the probable errors for the one degree and 20′ arcs. There has, therefore, been no material falling off in the accuracy of the additional results, though the series are only two-thirds as many as for the 20′ arcs.

Two advantages are expected to grow out of the additional work, — the first of which relates to the determination of corrections for special divisions. One of the microscopes is now supplied with threads at intervals of 4′ and 2′ asunder, and it is proposed to supply all the microscopes with this same system of threads. Thus, it will be possible and convenient to ascertain any division correction now unknown by a single step of 2′ or 4′ from a line for which the correction is already known.

Secondly, it was desired to obtain, through more material, more exact information in regard to the systematic character of the graduation, and in general to ascertain the probable value of the indications of the present investigation as to those subdivisions of the circle for which the corrections have not been measured.

Let us now suppose (what is undoubtedly true) that the subdivisions of a degree have been marked upon the circle by means of a scale, of which the zero in each instance has been made to coincide as nearly as possible with the smaller numbered of the limiting degree lines. For instance, in subdividing the space 284° to 285°, the initial zero of the scale was most probably applied to 284° 0′. This is evident from the fact that the space 284° 58′ to 285° 0′ has been found to exceed 2′ by nearly 2″. There are other, though less striking instances of this kind.

Accordingly the division-corrections of these circles may be considered to be a combination of three sources of error:

- *a*. Correction for error in placing the assumed zero of the scale at the proper angular distance from the assumed zero of graduation, — here termed fundamental corrections;
- *b*. Correction for errors of spacing in the subdivisions of the scale which was copied;
- *c*. Correction for errors from whatever source in the process of copying.

Let the zero of reference for the scale be defined as the mean of the lines 0′, 10′, 20′, 30′, 40′ and 50′ of the scale. The observed fundamental corrections, *a*, of the circles, will then be the mean of the corrections actually determined for the six points in that degree at intervals of 10′. The values of *a*, so determined for each of the circles, appear in the following table.

FUNDAMENTAL DIVISION-CORRECTIONS = *a*.

R	A	B	R	A	B	R	A	B
°	″	″	°	″	″	°	″	″
0	−0.06	−0.07	16	−0.04	−0.10	32	−0.04	−0.10
1	0.29	0.22	17	+0.03	0.01	33	−0.07	+0.02
2	0.33	0.38	18	−0.13	−0.08	34	+0.08	−0.20
3	0.57	0.44	19	0.34	.00	35	0.09	0.19
4	0.19	0.38	20	0.00	+0.08	36	0.18	0.31
5	0.16	0.21	21	0.26	0.01	37	0.21	0.26
6	0.19	0.15	22	0.14	0.04	38	0.21	0.30
7	0.21	0.02	23	0.20	0.05	39	0.14	0.06
8	0.42	−0.20	24	−0.29	0.03	40	0.26	0.11
9	0.21	+0.13	25	+0.36	+0.02	41	0.30	0.17
10	0.44	+0.04	26	0.21	−0.03	42	0.43	0.03
11	0.31	−0.03	27	0.03	+0.03	43	0.30	0.36
12	0.30	0.06	28	0.32	0.05	44	0.45	0.18
13	0.39	0.03	29	+0.10	0.16	45	0.51	0.31
14	−0.42	.00	30	−0.13	0.03	46	0.36	0.32
15	−0.12	−0.11	31	−0.18	+0.03	47	+0.35	−0.28
48	+0.32	−0.26	62	+0.22	−0.33	76	+0.11	−0.41
49	0.39	−0.12	63	−0.03	0.54	77	0.30	0.33
50	0.41	+0.04	64	−0.03	0.44	78	0.22	0.31
51	0.46	−0.23	65	+0.11	0.29	79	0.03	0.07
52	0.37	0.12	66	−0.02	0.29	80	0.30	0.16
53	0.16	0.25	67	+0.04	0.43	81	0.33	0.02
54	0.53	0.24	68	0.18	0.30	82	0.32	−0.20
55	0.38	0.31	69	+0.09	0.16	83	0.24	+0.08
56	0.38	0.36	70	−0.07	0.16	84	0.38	−0.04
57	0.53	0.34	71	0.18	0.38	85	0.20	0.18
58	0.54	0.43	72	0.35	0.34	86	0.05	0.26
59	0.36	0.23	73	0.39	0.14	87	0.27	0.16
60	0.65	0.32	74	−0.23	0.48	88	0.01	0.24
61	+0.08	−0.37	75	+0.37	−0.17	89	+0.09	−0.12

Contemplation of the 1080 known corrections, arranged in groups of six in each degree upon our computation sheets, bears most striking and convincing testimony as to evident systematic progression in the values of *a*, but, at the same time, also to the fact that several of the larger changes in the application of *a* as a correction are real, — the systematic correction becoming discontinuous between 50′ and 60′, and probably between 58′ and 60′.* Under these circumstances, and owing to the small probable error (0″.03 ±) of the values of *a*, it is decided to use them directly, though it might have been preferable at some points to adjust them to a curve of correction.

As to the errors, *b*, due to the systematic errors of the scale employed in subdividing degrees, there exist two sources of evidence. First, as to the nature of the error and the possibility of defining it short of an investigation of the entire circle, we have the testimony afforded by the 10′ arcs. The observed systematic corrections for the 10′ lines may be ascertained by subtracting the correction, *a*, from the actually observed corrections for each of the corresponding lines. The mean of a large number of these residuals, corresponding respectively to the successive lines, 0′, 10′, 20′, 30′, 40′, and 50′, may be regarded as quite free from casual errors, *c*, the maker's error of copying, and from the similar errors in the present determinations of the individual corrections. The observed results for the systematic corrections, *b*, for 10′ arcs collected in groups embracing ten single determinations in each, are appended.

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* Dr. AUWERS, in the course of a comparison of the two Berlin zones, deduced from observations upon two different Pistor and Martins Circles, has shown (*Cat. der Ast. Ges.*, *Elftes Stück*, p. 117) that at declination, 21°, there is a sudden change of 0″.7 in the relation of the declinations of the two series of observations. In our Circle A, in one position of the instrument, such changes of relation to a series of perfect observations might originate from uncorrected errors of graduation. Changes of 0″.7, or 0″.8 occur at Z.D.'s 15°, 25° and 75°, with smaller changes at other points; and the effect of these extend to 30′ each side of the point of change, — often to a much greater distance.

CIRCLE A.

R	0′	10′	20′	30′	40′	50′
°	″	″	″	″	″	″
5	+0.13	−0.18	+0.08	+0.04	+0.09	−0.15
15	0.16	0.14	0.15	0.05	0.00	0.21
25	0.09	0.16	0.16	0.01	+0.09	0.19
35	0.15	0.23	0.17	0.10	−0.02	0.16
45	0.12	0.17	0.16	0.08	0.00	0.19
55	0.00	0.16	0.15	0.12	+0.05	0.14
65	0.10	0.17	0.15	0.04	+0.07	0.19
75	0.16	0.10	0.20	0.04	−0.06	0.23
85	+0.16	−0.15	+0.15	+0.03	−0.04	−0.14
Means	+0.12	−0.16	+0.15	+0.06	+0.02	−0.18

CIRCLE B.

R	0′	10′	20′	30′	40′	50′
°	″	″	″	″	″	″
5	+0.07	−0.11	+0.12	+0.21	−0.10	−0.19
15	0.06	0.15	0.12	0.22	0.08	0.16
25	0.07	0.11	0.10	0.16	0.09	0.13
35	0.07	0.14	0.11	0.17	0.10	0.11
45	0.14	0.09	0.10	0.14	0.08	0.21
55	0.04	0.19	0.14	0.15	0.03	0.12
65	0.09	0.17	0.14	0.17	0.03	0.20
75	0.08	0.13	0.12	0.16	0.08	0.16
85	+0.08	−0.09	+0.11	+0.14	−0.07	−0.18
Means	+0.08	−0.13	+0.12	+0.17	−0.07	−0.16
Means of A and B	+0.10	−0.15	+0.13	+0.11	−0.03	−0.17

The agreement of these eighteen separate determinations of the systematic corrections for the 10′ arcs is very striking, and fully confirms the opinion in regard to the excellence of the graduations which I have expressed in the preceding article (*A.J.* 383, pp. 198, 199.) Perhaps there is really a small systematic difference between the two circles as to the graduations at 30′ and 40′. But the difference from the adopted mean is, in linear measure, less than 0.13μ, or $0^{\text{in}}{\cdot}000005$, and should be attributed to some small difference in polish, or illumination, of the scale at different times, rather than to different scales. These tables are, therefore, held to indicate that, as to the remaining unknown corrections for subdivisions of the 10′ arcs, one may assume, without material error, that the systematic corrections would be the same for both circles, and that these can be usefully determined from a limited number of observations.

In 1880, the division-corrections for each line of Circle A, within the limits, 37° 20′ to 42° 0′, and in corresponding portions of the other three quadrants, were ascertained. The corrections deduced for the lines, 2′, 4′, 6′, 8′, 12′, etc., have recently been deduced anew from the same material of observation, but upon the much improved basis of the new individual corrections for the lines at multiples of 10′, obtained in 1895–6. The probable error of determination of the interpolated lines for the mean of four microscopes is taken to be $\pm 0''.06$. If, now, from these corrections there be subtracted the fundamental corrections, a, for the respective degrees, combining the four quadrants in one result, we shall have the following table of

OBSERVED SYSTEMATIC SCALE-ERRORS = b.

	0′	2′	4′	6′	8′	10′	12′	14′	16′	18′
°	″	″	″	″	″	″	″	″	″	″
38	+0.35	+0.39	+0.27	+0.31	+0.27	−0.02	+0.19	+0.22	+0.32	+0.54
39	0.08	0.25	0.06	0.13	−0.09	0.17	+0.01	0.09	0.23	0.31
40	0.08	0.31	+0.12	0.12	+0.30	0.06	+0.16	+0.17	0.51	0.38
41	+0.28	+0.02	−0.13	+0.05	−0.02	−0.45	−0.10	−0.02	+0.21	+0.13
Means	[+0.10]	+0.24	+0.08	+0.15	+0.12	[−0.15]	+0.06	+0.12	+0.32	+0.34

	20′	22′	24′	26′	28′	30′	32′	34′	36′	38′
°	″	″	″	″	″	″	″	″	″	″
37	+0.10	−0.13	−0.12	−0.05	+0.29	+0.08	+0.25	+0.07	−0.08	−0.14
38	0.22	0.00	0.06	−0.03	0.21	−0.04	0.06	−0.02	0.26	0.11
39	0.15	+0.11	0.09	+0.09	0.28	+0.27	0.28	+0.21	0.08	−0.07
40	0.24	+0.14	0.06	−0.02	0.37	0.12	0.23	0.10	0.16	+0.08
41	+0.03	−0.10	−0.17	−0.13	+0.19	+0.20	+0.10	+0.03	−0.17	−0.19
Means	[+0.13]	0.00	−0.10	−0.03	+0.27	[+0.11]	+0.18	+0.08	−0.15	−0.09

	40′	42′	44′	46′	48′	50′	52′	54′	56′	58′
°	″	″	″	″	″	″	″	″	″	″
37	−0.04	0.00	−0.18	−0.12	−0.02	−0.14	+0.12	−0.04	+0.06	+0.15
38	0.03	−0.11	0.13	0.33	0.13	0.49	−0.13	0.29	−0.20	−0.02
39	−0.08	0.18	0.30	0.35	0.11	0.22	0.22	0.25	0.15	0.07
40	+0.01	0.04	0.30	0.36	−0.23	0.37	0.44	0.26	0.08	0.21
41	+0.05	−0.07	−0.13	−0.02	+0.11	−0.10	−0.16	−0.32	−0.26	−0.12
Means	[−0.03]	−0.08	−0.21	−0.24	−0.08	[−0.17]	−0.17	−0.23	−0.13	−0.05

The quantities in brackets are taken from the previous tables for 10′ arcs.

The systematic character of the residuals is apparent at a glance. The means, as they appear in the table, have been adopted as the provisional systematic corrections, b, and their probable errors (by comparison of pairs of separate determinations) are $\pm 0''.043$ and $\pm 0''.038$ for the mean of four and five determinations respectively, or $\pm 0''.04$ for all. In the course of time, the determination of corrections for special divisions is likely to accumulate further evidence as to the values of b.

It may now be considered a matter of some interest to inquire with what precision the actual individual errors of graduation of these circles may be represented by a proper combination of the fundamental corrections, a, with the scale corrections, b. Let e, as before, designate the maker's probable error of copying the scale; e'', the probable error of the determination of the correction to the mean of four lines in this investigation; $e' = I - (a+b)$, the observed value of e; I being employed to indicate an observed division-correction of this paper. The arcs that are multiples of 10′ afford 1080 values of e', of which the probable value is $\pm 0''.073$. But we have: $e^2 = e'^2 - e''^2$. The value of e'' is certainly not materially less than $\pm 0''.04$, and therefore the value of e is not materially greater than $\pm 0''.06$. This is exactly confirmed by the evidence of the few 2′ arcs, which give. $e = \pm\sqrt{(0.086)^2 - (0.06)^2} = \pm 0''.06$.

Considering 1080 determinations of I for the multiples of 10′ only six values of e' exceed $0''.3$; the largest is $0''.38$. Therefore, only once in a thousand instances should e be greater than $0''.3$, and only once in ten times, greater than $0''.15$. This means that probably the maker did not commit an error of copying an individual, single, line much greater than $0^{\text{m}}.00005$ in any instance, and only once in ten lines an error of more than one forty-thousandth of an inch. There are 21600 lines on the two circles.

Should the present investigation be extended to all the lines (not at all likely), it may be assumed that unless the true probable error of determination is brought down to $\pm 0''.06$, at least, the work would be worse than useless.

I shall assume that, for all arcs for which the individual corrections have been determined, except for the 2′ arcs, the probable error is not greater than $\pm 0''.05$; and as to the arcs for which the correction is predicted by means of the formula, $I = a + b$, that the probable error is $e = \pm\sqrt{\epsilon_a^2 + \epsilon_b^2 + e^2}$. Making the proper substitutions we have $e = \pm\sqrt{(0.035)^2 + (0.04)^2 + (0.06)^2} = \pm 0''.08$.

The accuracy of the graduations of the Olcott Meridian Circle, especially for Circle B, is manifestly of the first order, to which only a limited number of meridian circles belong. But with relation to such of these as were made by PISTOR and MARTINS, and very probably to others of like rank by other makers, it appears that the following conclusions among others may apply.

1. The systematic errors are an important part of the total error of graduation; and they can be ascertained by an amount of labor that ought to be considered reasonable. Astronomers should show at least as much interest in this matter of accuracy as instrument-makers evidently do.

2. Granting that the systematic errors have been well ascertained, the determination of individual corrections serves no adequately useful purpose unless the real probable error of determination, differentially, is decidedly less than $\pm 0''.06$. If the probable error is materially greater than this, it is positively disadvantageous to employ individual corrections as determined.

3. Astronomers should require a description of the essential points in the process by which their circles have been graduated, so that the investigation of their systematic errors may be conducted in the most intelligent, economical and effective way.

The system of subdividing circles by means of scales is to be commended on account of the ease and certainty with which the systematic corrections can be ascertained. This is assumed to be true under the supposition that such scales can be copied as accurately as evidently has been the case with the Albany Circles. Let the primary scale be a standard circle graduated to 10° with the utmost attainable accuracy and repeatedly verified. The first operation would be to copy this circle quickly. Let one of the 10° arcs of the engine-circle be subdivided to degrees, to be copied upon each one of the 10° spaces of the circle to be graduated. In the same manner, let an arc of one degree be provided upon the engine-circle for the subdivision of degrees. In this system it should be so arranged that the same scales (of large radius) would serve for the graduation of all circles, whatever their radii. Investigation of the engine-circle itself, and subsequent investigations of the circles graduated by it, would soon afford a mass of accurate and valuable information in regard to this particular system of circles, and, in the course of time, the labor of investigating a new circle would be reduced to its lowest terms.

CORRIGENDUM.

No. 375, p. 119, line 19. *for* $\Delta\delta = -3'\ 32''.0$ and $\delta = +60°\ 56'\ 15''.6$ *put* $-1'\ 56''.7$ and $60°\ 57'\ 50''.9$.

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AN EXPLANATION OF THE ERRORS IN THE THEORY AND TABLES OF THE MOON'S MOTION,

BY JOHN N. STOCKWELL.

It is now more than two hundred years since mathematicians began to apply the principles of the universal gravitation of matter to the explanation of the observed irregularities in the motions of the moon and planets; and, while their efforts have been attended with very gratifying success during this long period, there are still some small, though important perturbations to be accounted for. Indeed, the discrepancies between theory and observation at times have been of such a serious character as to render somewhat doubtful the correctness of the law of universal gravitation, as announced by Sir ISAAC NEWTON. But the persistent efforts of mathematicians have gradually overcome the difficulties of the problem; and at present there are only two inequalities of a serious nature remaining, to be accounted for; one of which relates to the motion of the *moon*, and the other to that of the planet *Mercury*.

The first serious discordance between theory and observation which confronted mathematicians, after the announcement of the law of universal gravitation by NEWTON, related to the motion of the *moon's* apogee. This was found by NEWTON and his immediate successors to be only about one-half of what it was known to be by observation; and a period of sixty years elapsed after the publication of the *Principia* in 1687, before the oversight committed in the calculation was detected and corrected. But in the meantime the discrepancy between observation and calculation had been attributed to a defect in the law of gravitation rather than to an erroneous or defective calculation. It was then found by CLAIRAUT that when the first calculation was corrected by the addition of the terms arising from the square of the sun's disturbing force, the theory would be found to agree very nearly with observation. This was the first great triumph of the theory of universal gravitation.

The second great discrepancy between theory and observation related to the motions of *Jupiter* and *Saturn*. Observations of these two planets seemed to indicate that one of them was perpetually retarded in its motion around the sun, while the other was in like manner accelerated; and it was an object of importance to ascertain whether these changes were merely temporary, or would always continue in the same direction. It is well known that LAPLACE subsequently explained the cause of these inequalities in the motions of *Jupiter* and *Saturn*, by showing that there was an equation arising from the mutual action of these two planets, and having a period of more than nine hundred years. This equation, although of the third order with respect to the eccentricities of the orbits of those two planets, derived its great value and importance from the near commensurability of their mean motions,— five times the mean motion of *Saturn* being very nearly equal to twice the mean motion of *Jupiter*. This equation showed why the mean motions of those two planets should be alternately accelerated and retarded. At one time these phenomena seemed to be incompatible with the law of universal gravitation, but they subsequently became one of the strongest proofs of its correctness; and thus occasioned a second great triumph of the law of universal gravitation.

A third subject of triumph related to the motion of the *moon*. The first discussion of the question took place in the year 1693, when Dr. EDMUND HALLEY, in the discussion of some ancient eclipses, discovered that the *moon* was then moving more rapidly than she did in ancient times. This conclusion of Dr. HALLEY's was confirmed about a half a century later by the researches of DUNTHORNE; and the most celebrated mathematicians of that day, EULER and LAGRANGE, undertook the difficult task of explaining the cause of the acceleration by the principle of universal gravitation. But they were unable to find any equations of a secular character arising from that cause; and as usual in such cases attributed it to other causes than that of gravitation, rather than to an oversight in their own calculations; and it was not accounted for until the year

1787, when LAPLACE proved that it was a legitimate effect of the principle of universal gravitation. LAPLACE, at the same time, showed that the motions of the perigee and nodes of the *moon's* orbit were also subjected to secular inequalities arising from the same cause, although no such inequalities had been discovered by observation. All these secular inequalities which were discovered by LAPLACE were subsequently confirmed by other investigators; and it was firmly believed that the mathematical theory of the *moon's* motion was fully perfected.

But notwithstanding these great improvements in the mathematical theory of the *moon's* motion, LAPLACE, about a century ago, made the following statement in the Introduction to his *Theory of the Moon*:

> "The numerous comparisons, which BURG and BOUVARD have made, of MASON'S tables, with the observations of the *moon*; at the end of the seventeenth century, by LAHIRE and FLAMSTEED; in the middle of the eighteenth century by BRADLEY; and the uninterrupted series of observations of MASKELYNE, from the time of BRADLEY to the year 1800, give a result which was wholly unexpected. The observations of LAHIRE and FLAMSTEED, being compared with those of BRADLEY, indicate a secular motion exceeding by fifteen or twenty centesimal seconds that which is inserted in the third edition of LALANDE'S astronomy, ... while BRADLEY'S observations, being compared with the last ones of MASKELYNE, give, on the contrary, a smaller secular motion, by at least one hundred and fifty centesimal seconds; and lastly, the observations made within the last fifteen or twenty years prove that the diminution of the *moon's* motion is now decreasing. Hence, it becomes necessary to vary incessantly *the epochs of the tables*; and it is an object of importance to correct this imperfection. This evidently indicates the existence of one or more inequalities of long period in the *moon's* motion which the theory alone can point out."

Such is the statement, by the great master of mathematical astronomy, of the problem which has confronted mathematicians during the past one hundred years; and which, according to a recent statement by Prof. NEWCOMB, who has given a good deal of attention to it during the past quarter of a century, is no nearer to a solution than when it was left by LAPLACE; and such is the problem of which the writer has undertaken to give the solution.

In this connection it is proper to observe that the *longitude of the epoch* is found by adding the mean anomaly to the longitude of the perigee at the same epoch, so that the longitude of the epoch and the longitude of the perigee are connected by a fixed relation. From this it follows that the mean longitude of the epoch would be equally affected by a perturbation of the mean longitude of the *moon*, or by an equivalent perturbation of the longitude of the perigee.

Now the writer gave, seven years ago in Nos. 220 and 221 of this Journal, a direct computation of the secular motion of the *moon's* perigee, from which it appeared that the terms of that motion which were multiplied by the square of the time should be *added to* the mean motion of the perigee, instead of being *subtracted from* it as found by LAPLACE and all subsequent investigators. At that time I found that the secular term in the motion of the perigee was equal to $+15''.61 \,.\, i^2$, i denoting centuries; while LAPLACE gave $-30''.55 \,.\, i^2$ for the same term. I have since employed my value of the secular motion of the perigee, in the computation of a large number of ancient eclipses, and have found a much better agreement with the traditions concerning them than would result from LAPLACE'S value of that acceleration.

The accurate computation of the motion of the *moon's* perigee is unquestionably the most intricate problem connected with the lunar theory; and my first attempt to determine the secular terms of that motion was only partially successful. But during the past year I have made a complete revision of all my former computations on the lunar theory; and I now find that my first computation of the secular term in question was considerably erroneous. The error arose from two causes. A part of it was occasioned by one term of the formula being just double its true value; and the other part was occasioned by overlooking a number of terms which contributed largely to the coefficient. I have now examined the subject with great care; and I find that the secular motion of the perigee should be $+53''.77 \,.\, i^2$ instead of $+15''.61 \,.\, i^2$ as first found. The new value of the coefficient retains the same sign as the old, and is nearly three and one-half times as large. If this term is approximately correct, it shows that LAPLACE'S secular term should be increased by $+84'' \,.\, i^2$; and if his secular term is wrong by that amount, it would necessarily follow that the *epochs* of the tables must incessantly change.

It may be said, however, that LAPLACE'S value of the secular equation is more probably correct than my own, because his results have been confirmed by the independent computations of other investigators. In fact Prof. NEWCOMB lays much stress on the accuracy of computations which have been thus confirmed; and I fully agree with him in so far as the detection of *accidental errors* is concerned. But the case is different when there are *systematic errors* to be taken into consideration; and a solution of a problem might be theoretically exact when affected by systematic errors; and the results might be very different from what they would have been had the systematic errors been first eliminated.

Systematic errors are frequently introduced into a problem by reason of some assumption or theory on the part of an investigator, for the purpose of simplification, or in order to evade some difficulty so as to render a solution possible. If such assumption is nearly correct the resulting solution of the problem will not differ greatly from the truth; but otherwise the results might be wholly erroneous. On this subject LaPlace speaks with extreme caution when he says: "Astronomy, considered in the most general manner, is a great problem of mechanics in which the elements of the motions are the arbitrary constant quantities. The solution of this problem depends, at the same time, upon the accuracy of the observations, and upon the perfection of the analysis. It is very important to reject every *empirical process*, and to complete the analysis so that it shall not be necessary to derive from observations any but indispensable data." And again, "Such is the weakness of the human mind, that it often requires the aid of a theory to connect together a series of observations. If we restrict a theory to this use, *and take care not to attribute to it a reality which it does not possess*, and afterwards frequently rectify it by new observations, we may finally discover the true cause, or at least the laws of the phenomena."

It is difficult to state more explicitly, or with greater precision and clearness, the causes which may contribute to vitiate the solution of a complicated mathematical problem; and I shall now show that LaPlace and his successors, in their respective theories of the *moon*, have not strictly conformed to the above statement of the principles which should govern the solution of physical problems.

The solution of the problem of finding the motion of one body around a second body, when the motion is disturbed by the attraction of a third body, requires the integration of three differential equations of the second order, in which the constants of integration are functions of the elements of the orbit of the disturbed body. These differential equations do not contain the time, t, explicitly, but merely its differential, dt; and the constants of integration correspond to the osculating elements which exist at the particular instant for which the differential equations are given. Now these osculating elements would be rigorously constant through all time if there were no disturbing forces. But since there are disturbing forces, these elements or constants change from one instant to another, and the general effect of these forces is to produce a moveable orbit without changing its form. The elements of the orbit are therefore rigorously constant in the differential equation, but they would vary in the integrals of these equations. Now, it has been the custom with mathematicians to assume that the perigee and nodes of the *moon's* orbit are in motion from the outset; or, in other words, that the constants introduced by the integrations are really variable. The *theoretical* effect of this assumption is to introduce into the expanded differential equations, terms depending on the variations of those elements; and the integration of these expanded differential equations requires the integral to be of a form involving the same assumption. But the *practical* effect is to slightly modify the coefficients of all the equations of short period depending on the configuration of the different bodies. In fact it makes the coefficients of the equations depending on perturbation all more or less empirical. It is far different, however, in regard to its effect on the secular equations. The assumption of the motion of the perigee and nodes of the lunar orbit enabled LaPlace to calculate the mean motion of those elements with a good deal of precision, by an *indirect process;* but the equations by which they were determined would have had no existence, except for the empiricism by which they were created. They also give secular changes in the *moon's* mean distance; also in the eccentricity and inclination of its orbit; whereas a direct calculation shows that there are no secular terms affecting these elements. The secular equation of the mean motion arises from a secular term in the expression for the radius vector, instead of the mean distance; but this distinction is unimportant except from a theoretical point of view.

A single example will suffice to illustrate these general considerations. In the *Mécanique Céleste*, book II, chap. II, LaPlace gives the following differential equation between the coordinates r, v and θ and their differentials, the element of time dt and the force $\left(\frac{dQ}{dv}\right)$;

$$\frac{d\left(r^2\cos^2\theta\,\frac{dv}{dt}\right)}{dt} = \left(\frac{dQ}{dv}\right) \qquad (1)$$

The integral of this equation is

$$r^2\cos^2\theta\,\frac{dv}{dt} = c + \int\left(\frac{dQ}{dv}\right)dt \qquad (2)$$

c being the arbitrary constant quantity. But if we suppose c to be variable, equation (2) would give by differentiation,

$$\frac{d\left(r^2\cos^2\theta\,\frac{dv}{dt}\right)}{dt} = \frac{dc}{dt} + \left(\frac{dQ}{dv}\right) \qquad (3)$$

Now equation (3) cannot be true unless $\frac{dc}{dt} = 0$, in which case it becomes identical with equation (1), from which it was first derived by integration. We must, therefore, in the solution of the differential equations regard the elements as rigorously constant. These considerations are of importance, since a mathematician of very high order (the late Prof. J. C. Adams) has maintained that every variable element that enters into the conditions of a problem should be treated as variable in all the differentiations and integrations which arise in the solution of the problem. This unfortunate conception has been the occasion of much controversy, and has led to many curious and erroneous results, some of which it may be proper here to point out.

Among these erroneous results may be mentioned the secular acceleration of the *moon's* mean motion by Prof. Adams, which was published in the *Philosophical Transactions of the Royal Society*, for 1853; and which was the occasion of an exciting controversy among European astronomers during several years afterwards. Then there is the inequality of long period in the *moon's* motion arising from the action of *Venus*, which was discovered by Hansen, in 1847. The coefficient of this inequality is equal to +16″.0, according to the investigations of Hansen and Delaunay; but it would be only +0″.018, if freed from empiricism; and yet Prof. Newcomb states in Vol. V, part III, *of Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac*, which was published in 1894, that, "*The most rigid examination into the subject has failed to show the possibility of any error in* Hansen's *result.*"

Further illustration seems unnecessary; but I do not claim that a perfect *theory of the perturbations* would represent the observations with greatly increased precision, since the *elements* on which existing tables are founded must partake of the empiricism of the theories involved in their construction. There is, however, no occasion for the further introduction of empiricism into astronomical theories, as proposed by Prof. Hall, and favored by Prof. Newcomb, by means of a modification of the law of universal gravitation; but it is vain to hope for further improvement of the lunar theory until it has been freed from the empiricism with which it is already encumbered.

Cleveland, 1897 *April* 22.

FUNDAMENTAL ERRORS IN THE ALMANAC POSITIONS OF THE PRINCIPAL OBSERVATORIES OF THE WORLD.

By J. M. SCHAEBERLE.

In 1895 I called attention to the fact that the almanac value of log ρ for the Lick Observatory was largely in error (*A.J.* 356). Recently I had occasion to examine the published values of log ρ for certain other observatories, and was amazed to find that they were all wrong. In one or two cases the error amounted to more than two thousand (2000) units of the seventh decimal place of log ρ.

In the present state of astronomy of precision it seems inexcusable to continue to publish the value of log ρ as though all observations were at sea level, when the altitude above sea level, in each case, is one of the best determined constants of a fixed observatory.

Lick Observatory, University of California, 1897 *May* 1.

THE PARALLAX OF 61^1 *CYGNI*, DEDUCED FROM THE RUTHERFURD PHOTOGRAPHIC MEASURES,

By HERMAN S. DAVIS.

Between 1871 Nov. 9 and 1874 June 13, nineteen negatives of the stars about 61^1 *Cygni* were made by Rutherfurd. The measures of these plates were placed in my hands by Prof. J. K. Rees, Director of the Observatory, to be reduced for parallax. The methods of reduction by differences of distance of two stars, having approximately equal distances and differing about 180° in position-angle, are the same as were employed for the parallax of μ and θ *Cassiopeiae* (1) and of η *Cassiopeiae* (2). But, whereas heretofore only measures of distance were used for parallax, in the present research I have used measures of angle also. For it has been recently shown (3) in the case of eight stars among the *Pleiades* whose average distance is 2160″, ranging from 631″ to 3160″, that the displacement on the arc of a great circle by reason of the probable error of observation is but little larger in measures of angle than of distance. It is proper to add that this research on the measures of 61^1 *Cygni* — a complete discussion of which will soon be published as *Contribution No.* 13 *from the Observatory of Columbia University* — has shown that, for the seven stars whose measurement of position-angle I have used, the probable error for one plate of unit weight is ±0″.1488 in angle, whereas for the eight stars used in distance it is ±0″.1912. Their average distance is only 1956″, ranging from 1075″ to 2754″. This fully corroborates Dr. Jacoby's conclusion (page 282) (3) and justifies the future use of position-angle for parallax determination in the case of all the Rutherfurd plates.

The results for parallax are given below. No observation was discarded, and I have used every star which was impressed upon the plates sufficiently often in both seasons of the year. The comparison-stars are:

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(1) The Parallaxes of μ and θ *Cassiopeiae*, by Harold Jacoby.

(2) The Parallax of η *Cassiopeiae*, by Herman S. Davis.

(3) The Permanence of the Rutherfurd Photographic Plates, by Harold Jacoby.

Star	Durchmusterung		Approximate position referred to 61^1 *Cygni*	
	Number	Mag.	Distance	Angle
			″	°
64	38°4372	7.8	3362	69.74
6	37°4159	7.5	2660	230.21
39	38°4353	8.4	3185	13.29
5	38°4325	6.0	2163	273.11
53	38°4362	7.8	2126	81.10
54	38°4363	9.1	2165	78.27
48	37°4189	7.9	1423	105.89
14	38°4336	8.8	971	296.79
37	37°4180	7.7	1337	149.62
27	37°4175	9.0	1075	177.26
48	37°4189	7.9	1423	105.89
43	37°4185	9.0	1825	143.85
32	37°4178	7.5	2156	172.68
23	38°4341	8.2	2501	356.08
13	38°4335	9.0	2754	341.41

From these stars are obtained the following values of the relative parallax:

	Stars	Parallax	Probable error	Prob. error of one equation
		″	″	″
Distance	64 and 6	+0.5211	±0.0373	±0.1641
	39 and 6	.4497	.0429	.2562
	5 and 53	.3733	.0400	.2020
	54 and 5	.2431	.0409	.1576
	48 and 14	+0.3888	±0.0658	±0.1840
Angle	37	+0.3028	±0.0354	±0.1018
	27	.3779	.0395	.1525
	48	.2794	.0473	.1758
	43	.3299	.0557	.1638
	32	.3442	.0620	.1293
	23	.3334	.0743	.1496
	13	+0.4401	±0.0819	±0.1646

The mean of these values from measures of distance is

+0″.3999 ±0″.0230

and from measures of position-angle

+0″.3326 ±0″.0189

from which results the mean relative parallax of 61^1 *Cygni*

+0″.360 ±0″.0146

Columbia University Observatory, New York City, 1897 *April* 30.

ELEMENTS OF THE ANNUAL COMPONENT OF THE POLAR MOTION FROM RECENT OBSERVATIONS,

By S. C. CHANDLER.

In *A.J.* 323 and 329 the fact was established that the annual motion of the terrestrial pole about its mean position on the earth's surface is from west to east in a very elongated ellipse having an eccentricity of 0.9638, the conjugate principal axes being 0″.30 and 0″.08, the major axis lying on a meridian 45° east of the Greenwich meridian, and the dates when the pole reaches the extremities of this axis (considered apart from the 428-day circular motion, of course) being April 6 and October 5.

These elements were derived from observations made previous to 1894. They have been used, in conjunction with those of the 428-day term derived from the observations from 1825 to 1890 (*A.J.* 322), in the tables for the prediction of the variations of latitude in 1896 and 1897 (*A.J.* 360 and 392).

Since the publication, in the places above cited, of this theory of the motion of the pole, synthetically deduced from observation, I have been interested to compare it with the various series of observations which have since appeared, not only for the purpose of verification and improvement of the numerical values of the various constants, but also to detect any additional characteristics which these later data might make apparent. The general result of these additional investigations has been merely a satisfactory confirmation of the previous deductions as to the nature of the law of these motions, without furnishing any material improvement of the numerical elements. Nevertheless, since they enable us to draw some interesting and important conclusions, and since, besides, many months must probably elapse before we can expect to see in print the results of the observations made during the past year, I may be pardoned for taking the space to describe some of these minor researches. Among these, one of the most interesting relates to a determination of the elements of the annual component of the polar motion based entirely on recent data (since 1894.0) and consequently absolutely independent of the older one above mentioned. The present paper will be limited to the presentation of this computation.

The range of this investigation is necessarily restricted to the period between 1894 January and 1895 August, the latter date marking the completion of Doolittle's series at Bethlehem. His new series at Philadelphia began in the autumn of 1896 but is not yet published. Of the series at Columbia University, by Rees, Jacoby and Davis, begun in the spring of 1893 and still current, we have the results for the first fourteen months; and it may be remarked in passing that it is a very fortunate circumstance that a portion of this series, yet unreduced, will bridge the gap in Doolittle's work rendered unavoidable by his removal from Lehigh University to the University of Pennsylvania.

For the corresponding interval 1894.0 – 1895.5 there have been published of the European observations those at Kasan, Potsdam, Karlsruhe and Strassburg.

The treatment of this material is analogous to that adopted in the former investigation of the observations up to 1894.0, with a slight variation for the purpose of abridging the calculation. Each series was compared with a curve of latitude-variation furnished by equation (59), *A.J.* 360, and the means of the differences, weighted according to the number of observations, for each interval of fifty days, were applied to the curve-values, so as to provide a series of normal observed latitude-variations. The results for Potsdam, Karlsruhe and Strassburg were combined (meridian of Berlin), and also those for Bethlehem and Columbia University. These normal values are given below: Kasan under I, Potsdam, Karlsruhe and Strassburg under II, and Bethlehem and Columbia under III.

NORMAL OBSERVED VALUES OF $\varphi-\varphi_0$.

t	I	II	III
	″	″	″
2412800	+0.12	+0.12	+0.08
2850	+ .12	+ .09	+ .02
2900	+ .08	+ .07	+ .03
2950	+ .02	+ .02	− .01
3000	+ .01	+ .05	− .09
3050	+ .02	.00	− .11
3100	.00	− .05	+ .04
3150	+ .02	+ .04	+ .09
3200	− .02	+ .02	+ .17
3250	− .03	− .10	+ .14
3300	− .02	− .03	+ .09
3350	+ .04	+ .03	− .09
3400	+0.09	+0.01	−0.16

The above values of the latitude-variation were then used to get the observed coordinates of the pole according to the formulas in *A.J.* 323, p. 83, as shown by the columns x, y, below:

t	x	y	x_2	y_2
	″	″	″	″
2412800	+0.030	−0.145	−0.074	−0.029
2850	− .018	− .100	− .015	+ .055
2900	+ .002	− .081	+ .110	+ .032
2950	− .014	− .017	+ .139	− .008
3000	− .079	− .015	+ .040	− .113
3050	− .088	+ .030	− .066	− .120
3100	+ .025	+ .035	− .060	− .092
3150	+ .061	− .064	− .085	− .100
3200	+ .135	− .065	+ .002	+ .008
3250	+ .106	+ .053	+ .058	+ .195
3300	+ .071	+ .003	+ .132	+ .141
3350	− .080	− .004	+ .055	+ .055
3400	−0.151	+0.029	−0.011	−0.020

From these values were subtracted the coordinates of the 428-day revolution according to the first terms of eq. (59), *A.J.* 360, p. 194, thus leaving the observed values for the annual term alone, x_2, y_2, in the last two columns. It should be remarked that, in the solutions from which x and y were found, weights were assigned to the various equations according to the number of the series used.

From the values x_2, y_2, general expressions were then found by least-squares, for each of the coordinates, according to the formulas near the bottom of the first column on p. 130, *A.J.* 329, after dividing the whole series into two portions, thus:

$$\begin{array}{rlll} & & \overset{m}{} & \overset{M}{} \\ 2412800\text{–}3100 & x_2 = +0.''006 & +0.''110 & \sin(\odot-295.^\circ3) \\ 3150\text{–}3400 & = +0.006 & +0.106 & \sin(\odot-293.6) \end{array}$$

$$\begin{array}{rlll} & & \overset{n}{} & \overset{N}{} \\ 2412800\text{–}3100 & y_2 = -0.''040 & +0.''088 & \sin(\odot-232.^\circ2) \\ 3150\text{–}3400 & = +0.013 & +0.152 & \sin(\odot-278.3) \end{array}$$

From these values of m, n, M, N, the elements of the ellipses were found by the additional formulas in the place last cited. These elements are shown in the last two lines of the table below. The first three sets of elements are copied from my former paper, *A.J.* 329, in order that a general comparison may be made.

T	L	ω	a	b
	°	°	″	″
1890 Apr. 11	20.9	44.7	0.309	0.112
1892 Apr. 1	10.6	51.4	.311	.054
1893 Mar. 27	5.4	23.4	.289	.082
1894 Mar. 27	5.5	58.1	.244	.141
1895 Apr. 4	13.3	34.6	0.368	0.046

I have already published provisional values for the ellipses of 1894 and 1895, but those in the present paper are much more certain, as they rest on the newer Potsdam series and that at Columbia, in addition to those formerly available.

A comparative scrutiny of the contents of the last table seems to warrant the following conclusions.

First, The accordance of the elements, derived independently from observations in five different revolutions, testifies to the reality of this annual motion and places the fact of its strong ellipticity beyond reasonable doubt.

Secondly, There is no evidence that the dimensions of the annual ellipse have sensibly altered, progressively, during the period under investigation; or that there is any abrupt deviation, from period to period, from a mean path, not explicable by unavoidable errors in the determination of it by observation.

Thirdly, The axis of this elongated vibratory motion is stationary upon the earth's surface on a meridian forty-five degrees east of Greenwich; or at least, if any progressive apsidal motion exists, it is too slow to be discernible within this five years' interval of observation.

In a subsequent paper I shall present some evidence bearing on questions connected with the 428-day component of the motion of the pole.

CORRECTION OF THE 336 PULKOWA *HAUPTSTERNE* FOR LATITUDE-VARIATION,

By S. C. CHANDLER.

The following table gives the corrections to the individual declinations of the 336 *Hauptsterne* (Nyrén's Catalogue of 1865.0), and consequently of the Berlin *Jahrbuch* places of these stars, on account of variation of latitude. The mode of computing them has been fully described in *A.J.* 296, pp. 63, 64. The necessity of applying these corrections — in using the *B.J.* declinations for the purpose of getting equator-points which shall be parallel to the true equator, in all hours of right-ascension — is at present beyond all reasonable doubt.

Pulkowa Vertical Circle Declinations (1865.0) of 336 *Hauptsterne*, Correction for Latitude-Variation.

No.	Corr.	No.	Corr.	No.	Corr.	No.	Corr.	No.	Corr.	No.	Corr.	No.	Corr.	No.	Corr.
	″		″		″		″		″		″		″		″
1	−0.06	43	−0.01	85	−0.17	127	0.00	169	−0.07	211	+0.08	253	+0.16	295	−0.04
2	+ .04	44	+ .10	86	.09	128	+ .08	170	.12	212	.02	254	.03	296	+ .18
3	.08	45	− .03	87	.09	129	− .13	171	.05	213	.13	255	.13	297	.00
4	.07	46	.12	88	.11	130	− .03	172	.03	214	+ .01	256	.02	298	+ .20
5	.01	47	− .08	89	.10	131	.00	173	.04	215	.00	257	.05	299	.06
6	.08	48	+ .03	90	.12	132	− .02	174	.16	216	− .02	258	.20	300	.18
7	.07	49	− .03	91	.23	133	+ .16	175	.13	217	+ .01	259	+ .11	301	.16
8	.03	50	.02	92	.10	134	− .03	176	− .01	218	− .05	260	.00	302	.08
9	.15	51	.03	93	.17	135	.13	177	+ .05	219	.00	261	+ .24	303	.05
10	+ .03	52	− .13	94	− .12	136	.03	178	− .07	220	.00	262	− .01	304	.23
11	− .07	53	+ .04	95	+ .08	137	.13	179	+ .05	221	+ .04	263	.00	305	+ .20
12	+ .07	54	+ .06	96	+ .03	138	.16	180	− .09	222	.18	264	− .06	306	− .01
13	− .03	55	− .02	97	− .10	139	.08	181	+ .02	223	.05	265	+ .01	307	+ .21
14	− .13	56	+ .12	98	.07	140	.02	182	.02	224	.05	266	+ .04	308	.06
15	+ .10	57	+ .02	99	.12	141	.06	183	+ .02	225	+ .04	267	− .03	309	.09
16	− .02	58	− .06	100	− .06	142	.10	184	.00	226	.00	268	.01	310	.26
17	.07	59	+ .06	101	+ .02	143	− .08	185	− .07	227	+ .08	269	− .01	311	.10
18	− .06	60	− .03	102	− .11	144	+ .01	186	.05	228	.01	270	+ .08	312	.10
19	.00	61	+ .06	103	.04	145	+ .06	187	− .01	229	+ .07	271	.06	313	.16
20	− .04	62	− .01	104	.16	146	− .14	188	+ .08	230	− .03	272	+ .09	314	.15
21	− .09	63	+ .02	105	.22	147	+ .01	189	+ .05	231	.02	273	− .05	315	.07
22	+ .02	64	.01	106	.12	148	+ .05	190	− .06	232	− .01	274	+ .06	316	+ .03
23	− .07	65	+ .04	107	.12	149	− .08	191	+ .19	233	.00	275	+ .06	317	− .01
24	+ .01	66	− .10	108	.14	150	.08	192	.04	234	+ .13	276	.00	318	+ .05
25	− .01	67	+ .02	109	.10	151	.12	193	+ .04	235	.03	277	+ .04	319	.10
26	.00	68	− .01	110	.05	152	.03	194	− .05	236	.04	278	.00	320	.14
27	− .09	69	+ .07	111	.02	153	.06	195	.00	237	.16	279	− .07	321	.02
28	+ .08	70	− .05	112	.19	154	.08	196	+ .02	238	.09	280	+ .07	322	.13
29	− .03	71	.14	113	.08	155	.02	197	.03	239	.12	281	− .01	323	.12
30	− .06	72	.13	114	.09	156	.03	198	.06	240	.03	282	+ .06	324	.06
31	+ .02	73	.15	115	.18	157	.06	199	.12	241	+ .13	283	.07	325	.04
32	− .12	74	− .30	116	− .02	158	.11	200	.09	242	− .04	284	.07	326	+ .07
33	− .05	75	+ .03	117	+ .02	159	.05	201	+ .04	243	.06	285	.02	327	− .02
34	.00	76	− .06	118	− .10	160	.22	202	− .03	244	− .06	286	+ .04	328	− .11
35	− .08	77	.00	119	.10	161	− .16	203	+ .14	245	+ .28	287	− .06	329	+ .10
36	− .04	78	− .02	120	.12	162	.00	204	− .04	246	.24	288	+ .01	330	.00
37	+ .02	79	.15	121	.08	163	− .11	205	.00	247	+ .16	289	− .05	331	+ .12
38	+ .02	80	.07	122	− .10	164	.17	206	− .05	248	− .04	290	+ .04	332	.07
39	− .06	81	.14	123	.00	165	− .15	207	− .02	249	+ .04	291	.03	333	.08
40	.02	82	.27	124	+ .02	166	+ .01	208	+ .02	250	− .02	292	.03	334	.02
41	.18	83	.18	125	− .03	167	− .14	209	.01	251	+ .07	293	.19	335	.05
42	−0.02	84	−0.10	126	+0.06	168	+0.01	210	+0.04	252	+0.05	294	+0.09	336	+0.02

Cambridge, Mass., 1897 *May* 10.

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE VASSAR COLLEGE OBSERVATORY,

BY MARY W. WHITNEY AND CAROLINE E. FURNESS.

1897 Greenwich M.T.	*	No. Comp.	Planet — * Δα	Planet — * Δδ	Planet's apparent α	Planet's apparent δ	log pΔ for α	log pΔ for δ	Obs.
					(168) *Sibylla.*				
Jan. 12 15ʰ 49ᵐ 51ˢ	4	11	+1ᵐ 9.15ˢ	− 1′ 12.9″	7ʰ 38ᵐ 19.50ˢ	+15° 1′ 12.2″	n9.154	0.605	F
30 18 10 38	2	9	−0 27.84	− 6 0.5	7 24 44.20	+15 38 38.1	9.453	0.627	W
					(90) *Antiope.*				
Feb. 4 15 11 55	3	8	+0 6.18	+ 4 3.2	9 40 18.30	+17 1 40.5	n9.428	0.604	W
					(24) *Themis.*				
Feb. 4 17 9 31	4	10	−1 33.77	− 6 28.3	7 35 54.94	+22 51 1.5	9.308	0.487	F
					(38) *Leda.*				
Feb. 23 16 55 9	5	8	+0 30.39	− 6 8.2	9 41 17.05	+ 7 4 44.8	8.838	0.699	W
24 13 16 42	5	9	−0 13.74	− 4 9.1	9 40 32.93	+ 7 6 43.8	n9.495	0.718	W
25 12 35 1	5	8	−1 3.40	− 1 51.1	9 39 43.28	+ 7 8 58.7	n9.556	0.726	W
					(275) *Sapientia.*				
Feb. 23 17 32 6	6	6	−1 27.22	+ 7 58.5	10 37 31.25	+12 0 18.2	8.510	0.640	F
24 16 25 48	7	10	−1 24.03	− 7 31.0	10 36 45.16	+12 7 13.2	n8.948	0.640	F
25 13 9 56	7	10	−2 4.60	− 1 10.0	10 36 4.61	+12 13 34.1	n9.589	0.699	F
					(16) *Psyche.*				
Feb. 24 16 51 26	8	10	+0 41.98	+10 18.6	10 23 0.23	+10 27 20.4	n8.060	0.659	F
27 17 59 34	9	9	+0 42.18	− 8 34.9	10 20 35.78	+10 43 19.3	9.169	0.662	F
Mar. 4 18 3 41	10	11	+0 17.05	− 3 55.4	10 16 45.61	+11 9 2.5	9.296	0.662	F
10 16 24 18	11	12	−0 10.06	−10 25.5	10 12 9.83	+11 37 19.6	8.810	0.645	F
					(198) *Ampella.*				
Feb. 27 15 51 29	12	12	+0 11.61	+ 5 57.0	9 38 34.86	+ 1 3 15.5	n8.270	0.758	W
Mar. 4 17 31 29	13	6	+2 14.96	+ 2 54.3	9 34 21.22	+ 1 27 35.4	9.325	0.756	W
6 18 6 47	14	8	+1 10.99	+ 0 9.2	9 32 46.91	+ 1 37 18.4	9.451	0.756	W

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	7ʰ 37ᵐ 7.95ˢ	+2.40ˢ	+15° 2′ 25.1″	0.0″	Auwers, Berlin A.G.C. 2991
2	7 25 9.49	+2.55	+15 44 38.7	− 0.1	" " " 2870
3	9 40 9.46	+2.66	+16 57 46.2	− 8.9	" " " 3919
4	7 37 25.99	+2.72	+22 57 29.6	+ 0.2	Becker, " " 3089
5	9 40 44.05	+2.62	+ 7 11 2.9	−10.0	$\frac{1}{3}$ (Romb. 2168 + Yarn. 4148 + Paris 12002)
6	10 38 55.79	+2.68	+11 52 32.7	−13.0	Leipzig A.G.C. 4099
7	10 38 6.49	+2.70	+12 14 57.3	−13.1	Romberg 2342
8	10 22 12.57	+2.68	+10 17 14.0	−12.2	$\frac{1}{4}$ (Radc.(2) 1036 + Yarn. 4443 + Glas.(1) 2724 + Paris 12823)
9	10 19 50.87	+2.73	+10 52 6.4	−12.2	Leipzig A.G.C. 4017
10	10 16 25.82	+2.74	+11 13 9.8	−11.9	$\frac{1}{3}$ (Glas. 2691 + Yarn. 4401 + Paris 12686)
11	10 12 17.16	+2.73	+11 47 56.7	−11.6	$\frac{1}{3}$ (Yarn. 4377 + Schj. 3769 + Paris 12601)
12	9 38 20.76	+2.49	+ 0 57 29.1	−10.6	Boss, Albany A.G.C. 3854
13	9 32 3.79	+2.47	+ 1 24 51.5	−10.4	" " " 3827
14	9 31 33.48	+2.44	+ 1 37 19.7	−10.5	Bonn VI. +1°2330

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An Explanation of the Errors in the Theory and Tables of the Moon's Motion, by Prof. John N. Stockwell.
Fundamental Errors in the Almanac Positions of the Principal Observatories of the World, by Prof. J. M. Schaeberle.
The Parallax of 61¹ Cygni, Deduced from the Rutherfurd Photographic Measures, by Dr. Herman S. Davis.
Elements of the Annual Component of the Polar Motion from Recent Observations, by Dr. S. C. Chandler.
Correction of the 336 Pulkowa Hauptsterne for Latitude-Variation, by Dr. S. C. Chandler.
Observations of Minor Planets, by Prof. Mary W. Whitney and Miss Caroline E. Furness.

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MEASURES OF THE DIAMETERS OF *MARS* AND THE POSITIONS OF HIS SATELLITES IN 1894,

MADE WITH THE 36-INCH EQUATORIAL OF THE LICK OBSERVATORY,

By E. E. BARNARD.

The following observations of the satellites of *Mars* were obtained in 1894 with the 36-inch.

The measures for position-angle were made by bisecting the satellite and the apparent center of *Mars*. No correction has been applied to them for any displacement of the center of figure from the effects of phase.

The distance-measures have been made usually from the nearest limb of the planet and the observations corrected for phase when required — this occurred in only one case, in the second set of observations of *Phobos* on October 15, when the distance was measured from the phase-limb.

In the distance-measures, on each night (except for *Phobos* on Sept. 23, Oct. 14 and 15) the latter half of the measures were made with the movable and fixed wires interchanged from what they were in the first half — the measures thus depending on double distances.

The observations of these satellites are not as numerous as I had hoped to make them. During the favorable position of the planet the time given to it was mainly taken up with physical observations of its surface; a large number of interesting drawings being secured, which are yet to be published.

On several dates the relative light of the two satellites was estimated:

1894 *Sept.* 23, 14^h 0^m. *Phobos* is nearly twice as bright as *Deimos.*

Oct. 14, 11^h 40^m. *Phobos* a little brighter than *Deimos*; about $\frac{1}{3}$ magnitude.

Oct. 21, 9^h 0^m. *Phobos* is nearly $\frac{1}{2}$ magnitude brighter than *Deimos.*

Oct. 29, 8^h 0^m. *Phobos* is nearly 1 magnitude brighter than *Deimos.*

These observations make *Phobos* considerably brighter than *Deimos*, and this is in accord with previous observations.

A series of measures of the polar and equatorial diameters of *Mars* was also obtained and the results are here given.

POLAR DIAMETER OF *Mars*, 1894.

Pacific Stand. Time			Observed	Δ unity	D	Resid.
	d	h m	″	″	″	″
July	30	18 0	13.52	9.46	9.45	+0.13
Aug.	13	17 52	15.06	9.43	9.42	+0.16
Sept.	30	12 40	21.50	9.50	9.49	+0.09
Oct.	7	14 15	22.04	9.53	9.52	+0.06
	15	9 50	22.58	9.75	9.74	−0.16
	21	9 45	22.05	9.67	9.66	−0.08
	28	10 10	21.31	9.65	9.64	−0.06
	29	8 30	21.26	9.68	9.67	−0.09
Nov.	4	9 15	20.24	9.61	9.60	−0.02
	5	9 15	20.22	9.64	9.63	−0.05
	11	8 40	19.05	9.58	9.60	+0.01
				Mean	9.584	

D is the final value corrected for inclination of the axis. This corresponds to a diameter of 4312 miles.

EQUATORIAL DIAMETER OF *Mars*, 1894.

Pacific Stand. Time			Observed	Δ unity	Resid.
	d	h m	″	″	″
July	30	17 55	11.55	9.45	+0.22
Oct.	7	14 10	22.16	9.69	+0.02
	15	9 45	22.68	9.81	−0.14
	21	9 40	22.18	9.73	−0.06
	28	10 15	21.32	9.67	0.00
	29	8 35	21.27	9.73	−0.06
Nov.	4	9 10	20.12	9.67	0.00
	5	9 10	20.06	9.69	−0.02
	11	8 45	18.67	9.62	+0.05
			Mean	9.673	

This corresponds to a diameter of 4352 miles.

The measures have been corrected for phase and reduced to distance unity.

The "polar diameter" is the one through the polar cap, while the "equatorial" is that at right angles to it.

They give for the polar compression of *Mars*,

$$\frac{E-P}{E} = \frac{1}{109}$$

The two sets correspond to a mean diameter of 4332 miles.

OBSERVATIONS OF *Phobos*, 1894.

September 23.

Pacific Stand. Time	From f. limb	From center	Pos. Ang.	
h m s	″	″	°	
10 59 53	. .	. .	50.9	Satellite very bright. It is a bright object with *Mars* in field
11 1 23	. .	. .	52.2	
11 2 22	. .	. .	52.8	
11 3 12	. .	. .	52.3	
11 5 15	18.01	28.62	. .	Reduction semi-diameter = 10″.61.
11 7 36	17.64	28.25	. .	
11 8 36	17.52	28.13	. .	

September 30.

Pacific Stand. Time	From f. limb	From center	Pos. Ang.	
h m s	″	″	°	
14 37 7	. .	. .	242.2	Frequent fogging of O.G.
14 38 4	. .	. .	240.7	
14 39 47	. .	. .	240.0	
14 40 56	. .	. .	239.7	
14 43 50	37.02	26.04	. .	Reduction semi-diameter = 10″.98
14 45 20	37.68	26.70	. .	
14 46 47	37.06	26.08	. .	
14 48 32	38.24	27.26	. .	
14 49 42	38.28	27.30	. .	
14 51 54	38.18	27.20	. .	

October 7.

Pacific Stand. Time	From f. limb	From center	Pos. Ang.	
h m s	″	″	°	
8 50 58	. .	. .	216.7	Wind shaking telescope
8 52 31	. .	. .	215.4	
8 53 12	. .	. .	215.0	Reduction semi-diameter = 11″.20
8 54 6	. .	. .	214.6	
8 56 6	34.55	23.35	. .	
8 57 10	33.58	22.38	. .	
8 58 4	33.46	22.26	. .	
8 59 41	32.79	21.59	. .	
9 0 46	32.28	21.08	. .	
9 1 46	32.28	21.08	. .	

October 14.

Pacific Stand. Time	From f. limb	From center	Pos. Ang.	
h m s	″	″	°	
11 38 36	. .	. .	60.6	High wind shaking telescope. Seeing very bad
11 40 6	. .	. .	61.3	
11 41 36	. .	. .	60.5	
11 42 46	. .	. .	58.9	
11 44 6	. .	. .	58.5	Reduction semi-diameter = 11″.23
11 41 16	17.37	28.60	. .	
11 47 36	17.11	28.34	. .	
11 48 46	17.36	28.59	. .	

October 15.

Pacific Stand. Time	From f. limb	From center	Pos. Ang.	
h m s	″	″	°	
11 5 50	. .	. .	53.3	Seeing 4
11 7 35	. .	. .	52.9	
11 8 40	. .	. .	52.9	
11 9 30	. .	. .	51.4	Reduction semi-diameter = 11″.22
11 10 25	. .	. .	51.6	
11 13 5	19.51	30.73	. .	
11 14 2	18.55	29.77	. .	
11 14 55	19.31	30.53	. .	
11 15 55	19.66	30.88	. .	
14 16 12	. .	. .	242.4	Seeing poor now
14 17 17	. .	. .	241.4	
14 18 32	pr. limb	. .	241.1	
14 24 7	15.29	26.47	. .	Reduction semi-diameter = 11″.18
14 25 12	15.48	26.66	. .	
14 26 42	15.20	26.38	. .	
14 27 37	16.00	27.18	. .	

October 21.

Pacific Stand. Time	From pr. limb	From center	Pos. Ang.	
h m s	″	″	°	
8 33 20	. .	. .	233.0	Seeing 1–2
8 35 17	. .	. .	234.4	
8 36 27	. .	. .	233.3	
8 37 26	. .	. .	232.4	Reduction semi-diameter = 11″.20
8 40 5	18.37	29.57	. .	
8 41 31	17.96	29.16	. .	
8 42 31	17.40	28.60	. .	
8 43 35	17.49	28.69	. .	
8 44 45	17.64	28.84	. .	
8 46 5	17.62	28.82	. .	

October 28.

Pacific Stand. Time	From pr. limb	From center	Pos. Ang.	
h m s	″	″	°	
9 38 50	. .	. .	220.5	Wind shaking telescope badly.
9 40 20	. .	. .	221.0	
9 42 5	. .	. .	218.6	
9 43 32	. .	. .	218.6	Seeing poor
9 45 25	. .	. .	219.8	Reduction semi-diameter = 10″.71
9 47 58	12.86	23.57	. .	
9 50 0	12.22	22.93	. .	
9 51 18	11.55	22.26	. .	
9 52 18	11.36	22.07	. .	
9 53 41	11.28	21.99	. .	
9 55 12	10.66	21.37	. .	

October 29.

Pacific Stand. Time	From pr. limb	From center	Pos. Ang.	
h m s	″	″	°	
7 47 24	. .	. .	234.7	Seeing good
7 49 9	. .	. .	234.7	
7 50 22	. .	. .	234.6	
7 51 24	. .	. .	234.9	
7 56 22	17.28	27.92	. .	Reduction semi-diameter = 10″.64
7 58 2	17.51	28.15	. .	
7 59 7	17.33	27.97	. .	
8 0 12	17.29	27.93	. .	
8 1 37	17.67	28.31	. .	
8 2 27	17.43	28.07	. .	

November 4.

Pacific Stand. Time	From pr. limb	From center	Pos. Ang.	
h m s	″	″	°	
8 45 7	. .	. .	244.0	Seeing 3–4
8 47 33	. .	. .	244.0	No wind
8 48 33	. .	. .	242.7	
8 49 36	. .	. .	243.4	Reduction semi-diameter = 10″.20
8 51 46	14.27	24.47	. .	
8 53 6	14.21	24.41	. .	
8 54 6	14.83	25.03	. .	
8 54 59	14.77	24.97	. .	
8 56 16	14.61	24.81	. .	
8 57 16	15.35	25.55	. .	

November 5.

Pacific Stand. Time	From pr. limb	From center	Pos. Ang.	
h m s	″	″	°	
8 15 20	. .	. .	231.6	Seeing very bad. Satellite seen with difficulty
8 17 55	. .	. .	234.1	
8 19 25	. .	. .	233.6	
8 20 18	. .	. .	233.3	
8 22 55	16.30	26.41	. .	Wind shaking telescope
8 23 55	15.79	25.90	. .	
8 24 55	16.02	26.13	. .	Reduction semi-diameter = 10″.11
8 26 15	16.85	26.96	. .	
8 28 15	15.94	26.05	. .	
8 30 15	16.17	26.28	. .	
8 31 37	16.36	26.47	. .	

November 12.

Pacific Stand. Time	From pr. limb	From center	Pos. Ang.	
h m s	″	″	°	
9 11 12	. .	. .	224.4	South wind shaking telescope badly
9 13 10	. .	. .	222.9	
9 14 6	. .	. .	222.2	
9 15 12	. .	. .	221.0	Seeing good
9 19 45	11.78	21.27	. .	Reduction semi-diameter = 9″.49
9 20 42	12.44	21.93	. .	
9 21 45	12.67	22.16	. .	
9 22 42	12.96	22.45	. .	
9 24 0	11.89	21.38	. .	
9 25 20	12.55	22.04	. .	

Observations of *Deimos*, 1894.

September 30.

	f. limb			
h m s	″	″	°	
13 56 52	. .	. .	68.2	Satellite not well seen
13 58 45	. .	. .	66.6	
14 0 2	. .	. .	66.7	
14 1 29	. .	. .	67.2	
14 3 27	44.43	55.41	. .	Reduction semi-diameter = 10″.98
14 4 35	45.08	56.06	. .	
14 5 57	44.64	55.62	. .	
14 8 27	45.43	56.41	. .	
14 9 32	46.09	57.07	. .	
14 11 9	44.91	55.89	. .	

October 21.

Pacific Stand. Time	From pr. limb	From center	Pos. Ang.	
h m s	″	″	°	
8 52 18	. .	. .	255.7	
8 53 20	. .	. .	254.5	
8 54 15	. .	. .	253.9	Reduction semi-diameter = 11″.20
8 55 5	. .	. .	254.1	
8 57 37	40.43	51.63	. .	
8 58 42	40.51	51.71	. .	
8 59 37	40.61	51.81	. .	
9 0 50	41.03	52.23	. .	
9 2 20	41.18	52.38	. .	
9 3 35	41.24	52.44	. .	

November 4.

h m s	″	″	°	
8 2 56	. .	. .	241.9	
8 4 31	. .	. .	242.2	
8 5 36	. .	. .	241.9	
8 6 26	. .	. .	242.5	
8 8 41	53.51	63.71	. .	
8 9 51	53.22	63.42	. .	Reduction semi-diameter = 10″.20
8 10 6	53.16	63.36	. .	
8 14 16	53.67	63.87	. .	
8 15 31	53.63	63.83	. .	
8 16 36	54.08	64.68	. .	

Corrections for refraction have, in the main, been insensible and have not been applied to any of the observations.

Yerkes Observatory, Williams Bay, Wisconsin, 1897 *May* 13.

NOTE ON MR. CHANDLER'S ARTICLE "ON NYRÉN'S VERTICAL-CIRCLE OBSERVATIONS 1882–91," *A. J.* 400,

By M. NYRÉN.

La remarque de M. Chandler sur l'erreur commise par moi dans l'emploi des résidus p. (39) du "Déduction des Déclinaisons moyennes pour 1885.0" est parfaitement correcte. Déjà dans l'examplaire du dit mémoire que je m'étais permis, il y a deux mois, de présenter à M. Chandler, j'avais indiqué comme "prématurées" les conclusions tirées de ce procédé.

Expliquer ici par quelle voie cette inadvertance ait pu se glisser dans la rédaction définitive serait trop long.

Le regret de M. Chandler que, dans la déduction des positions définitives du Catalogue, on n' ait pas pris en considération aussi le terme annuel de la variation de la latitude, me paraît facile à dissiper. Dans l'Introduction au vol. II des *Publications* on trouve rassemblées toutes les observations des étoiles isolées avec leur moyennes et les jours d'observations. On y voit les différentes corrections pour la modification de la réfraction aini que pour la période de 14 mois de la latitude. Les astronomes qui se sont convaincus de la réalité et de l'exactitude des corrections exigées par les formules de M. Chandler seront donc, presque sans calculs, en état de pousser l'approximation au degré voulu.

NOTES ON VARIABLE STARS, — No. 18,

By HENRY M. PARKHURST.

Factors. Taking the geometrical means of the factors for 166 maxima of 132 stars, I obtain 0.64 and 0.68 for the average. From 35 minima of 32 stars, I obtain 1.05 and 1.07.

U Arietis. My observed intervals have been 345, 365 and 385 days. The following sine elements approximately represent all the observations:

$$2412782 + 376\,E + 30\,(\sin 40^\circ E + 180^\circ).$$

The comparative faintness of the photographic measures may be accounted for by the redness of the star.

RESULTS OF OBSERVATIONS.

No.	Star	Phase	Observed Date Julian	Observed Date Calendar	E	Corr.	W	Mag.	Factors			Remarks
				1896-7								
976	*T Arietis*	Min.	3880	Nov. 16	28	− 6	9P	9.83	1.10	1.13	29^d	
..	..	Max.	3963	Feb. 7	28	−50	8	9.00	2.1	3.6	54	Sky conditions bad
1113	*U Arietis*	Max.	3886	Nov. 22	4	+27	9	–	–	–	–	See note above
1166	*X Ceti*	Min.	3870	Nov. 6	–	–	1	–	–	–	–	May have been earlier
..	..	Max.	3965.9	Feb. 9	–	–	9	9.37	0.70	0.52	18	$nP = 566^d$, approx.
1222	*R Persei*	Max.	3854	Oct. 21	61	+10	8P	–	–	–	–	My last corr. was +13 [reduced
1357	*U Eridani*	Min.	3900 : :	Dec.	–	–	1	–	–	–	–	Appeared in Jan. Obsns. not yet
1386	*T Eridani*	Min.	3966	Feb. 10	11	–	E	–	–	–	–	Invisible in February
1577	*R Tauri*	Max.	3948	Jan. 23	39	+11	7P	9.1	1.1	1.0	32	
1582	*S Tauri*	Max.	3939	Jan. 14	36	−34	4	–	–	–	–	
1717	*V Tauri*	Max.	3898	Dec. 4	52	+ 3	3P	–	–	–	–	Mean of highest obsns.
1771	*R Leporis*	Min.	3956	Jan. 31	28	+21	7	9.71	1.5	2.1	57	
1800	*W Orionis*	Max.	3913	Dec. 19	–	–	9	6.41	3.3	1.7	48	Irregular fluctuation
1805	*V Orionis*	Max.	3908	Dec. 14	8	+ 2	8	–	–	–	–	No second crest seen
1944	*S Orionis*	Max.	4002	Mar. 18	24	− 4	9	8.49	0.45	0.65	11	Possibly another max. later
..	..	Max.	4014	Mar. 30	24	+ 8	9P	–	–	–	–	
2100	*U Orionis*	Max.	3992	Mar. 8	11	−10	3P	5.8	–	–	–	
2266	*V Monocerotis*	Min.	3999	Mar. 15	16	–	E	12.9]	–	–	–	Midway; at least 20^d later
2445	*W Monocerotis*	Max.	3990	Mar. 6	13	−39	6	9.85	2.3	1.4	94	
2478	*R Lyncis*	Min.	3999	Mar. 15	22	–	E	–	–	–	–	Invisible 69^d before min.
2539	*R Canis minoris*	Max.	3951.3	Jan. 26	41	+17	9	7.57	0.83	1.01	30	(+50)
2684	*S Canis minoris*	Min.	4032	Apr. 17	38	–	E	–	–	–	–	Probably later
2690	*X Puppis*	Max.	4005	Mar. 21	–	–	9P	8.1	0.6	0.7	28	Possibly later
2742	*S Geminorum*	Max.	4000	Mar. 16	56	−10	7	9.36	0.50	0.70	27	
..	..	Max.	4003	Mar. 19	56	− 7	6P	–	–	–	–	
2780	*T Geminorum*	Max.	3922	Dec. 28	61	−21	6	8.7	1.7	1.7	25	Corr. agrees with last year

INDIVIDUAL OBSERVATIONS.

Including Observations by ARTHUR C PERRY.

976 *T Arietis.*

Julian	Calendar		Mag.
	1896-7		
3841.6	Oct.	8	9.8P
3842.6		9	9.3P
3848.6		15	9.7P
3859.5		26	9.7P
3862.6		29	9.5P
3866.6	Nov.	2	9.7P
3870.6		6	9.9P
3886.5		22	9.8P
3890.6		26	9.7P
3897.7	Dec.	3	9.7P
3901.7		7	9.5P
3904.6		10	9.9P
3905.6		11	9.7P
3918.6		21	9.2P
3934.5	Jan.	9	9.25_2
3948.6		23	9.6P
3960.5	Feb.	4	8.7
3969.5		13	8.77_2
3970.5		14	9.18_2
3979.6		23	8.96_2
3988.5	Mch.	4	9.09_2
3988.5		4	9.4P
3998.5		14	9.13_2
4010.5		26	9.18_2

1113 *U Arietis.*

(Cont. from 377. Comp. Stars 314)

Julian	Calendar		Mag.
	1896-7		
3842.6	Oct.	9	9.9
3848.6		15	9.23_2
3866.6	Nov.	2	8.85_2
3867.5		3	8.60_2
3878.5		11	7.98_2
3904.5	Dec.	10	8.18_2
3914.5		20	9.07_2
3919.5		25	9.32_2
3930.6	Jan.	5	9.45_2

1166 *X Ceti.*

Julian	Calendar		Mag.
	1896-7		
3922.6	Dec.	31	10.2
3930.5	Jan.	5	10.42_2
3933.5		8	10.11_2
3935.5		10	10.08_2
3943.5		18	10.23_2
3948.5		23	10.12_2
3955.5		30	9.64_2
3965.5	Feb.	9	9.28_2
3967.5		11	9.37_2
3969.5		13	9.43_2
3970.5		14	9.53_2
3979.5		23	9.65_2

1222 *R Persei.*

(Continued from 377.)

Julian	Calendar		Mag.
	1896		
3841.6	Oct.	8	8.7P
3842.7		9	8.9P
3848.6		15	8.8P
3859.6		26	8.7P
3862.7		29	8.7P
3866.6	Nov.	2	8.9P
3870.6		6	8.9P
3886.5		22	9.8P
3890.6		26	10.0P
3897.7	Dec.	3	10.2P

1577 *R Tauri.*

(Continued from 377.)

Julian	Calendar		Mag.
	1896-7.		
3901.7	Dec.	7	10.5P
3905.6		11	9.7P
3918.6		24	9.6P
3931.6	Jan.	6	9.1P
3936.6		11	9.31
3936.6		11	9.3P
3943.6		18	9.0P
3948.5		23	9.08_2
3948.6		23	9.1P
3956.5		31	9.33_2
3975.5	Feb.	19	9.65_2

1582 *S Tauri.*

(Continued from 377.)

Julian	Calendar		Mag.
	1897		
3931.6	Jan.	6	10.3P
3933.5		8	10.33_2
3936.6		11	10.11_2
3948.5		23	10.41_2
3948.6		23	10.5P
3956.5		31	10.33_2
3975.5	Feb.	19	10.43_2

1717 *V Tauri.*

(Continued from 350.)

Julian	Calendar		Mag.
	1896-7		
3842.7	Oct.	9	12]P
3848.6		15	12]P
3862.7		29	11.5P
3866.7	Nov.	2	11.5P
3870.6		6	11.5P
3890.6		26	11.3P
3897.7	Dec.	3	10.6P
3899.5		5	10.4P
3904.6		10	11.2P
3905.6		11	11.2P
3918.6		24	11.4P
3931.6	Jan.	6	12.3P

1771 *R Leporis.*

Julian	Calendar		Mag.
	1896-7		
3640.6	Mar.	21	8.31_3
3934.5	Jan.	9	9.13_2
3936.6		11	9.38_2
3956.6		31	9.75_2
3979.6	Feb.	23	9.37_2
3991.5	Mar.	7	9.35_2
3994.5		10	9.42_2

1800 *W Orionis.*

(Cont. from 377.Comp.stars 377)

Julian	Calendar		Mag.
	1896-7		
3870.6	Nov.	6	6.52_3
3905.6	Dec.	11	7.11
3908.6		14	6.09_2
3914.5		20	6.23_2
3922.5		28	6.73_2
3932.5	Jan.	7	6.71_2
3954.5		29	6.66_2
3965.6	Feb.	9	6.49_2
3980.5		24	6.82_2

1805 *V Orionis.*

(Continued from 377.)

Julian	Calendar		Mag.
	1896		
3897.6	Dec.	3	10.3
3901.5		7	9.99_2

1805 *V Orionis*.—Cont.

Julian	Calendar	Mag.
	1896-7	
3905.5	Dec. 11	9.60_2
3908.5	14	10.05_2
3914.5	20	9.65_2
3921.5	27	10.10_2
3931.6	Jan. 6	9.96_2
3935.5	10	9.89_2

1944 *S Orionis*.

(Continued from 377.)

	1897	
3957.5	Feb. 1	11.8
3984.5	28	10.1
3988.5	Mar. 4	9.74_2
3988.6	4	9.5P
3991.5	7	9.4P
3994.6	10	9.3P
3995.5	11	9.02_2
3998.5	14	8.39_2
3999.5	15	8.44_2
4000.5	16	8.79_2
4005.5	21	8.38_2
4005.5	21	8.6P
4008.5	24	8.63_2
4010.6	26	8.7P
4012.5	28	8.83_2
4013.5	29	8.65_2
4014.6	30	8.6P
4016.6	Apr. 1	8.4P
4026.5	11	9.1P
4032.5	17	9.3P
4034.6	19	9.4P

2100 *U Orionis*.

(Continued from 377.)

Julian	Calendar	Mag.
	1897	
3988.6	Mar. 4	5.9P
3991.5	7	5.8P
3994.6	10	5.8P
4005.6	21	5.9P
4010.6	26	6.0P
4014.5	30	5.93_2
4014.6	30	6.3P
4016.6	Apr. 1	6.3P
4026.5	11	6.4P
4032.5	17	6.5P
4034.6	19	6.7P
4035.5	20	6.57_2

2266 *V Monocerotis*.

(Continued from 350.)

	1897	
3932.5	Jan. 7	10.4
3933.5	8	9.68_2
3956.6	31	12.5:
3980.6	Feb. 24	12.2
3988.5	Mar. 4	12.6
4008.5	24	12.9
4014.5	30	12.8]
4033.5	Apr. 18	12.9]

2445 *W Monocerotis*.

(Continued from 377.)

	1897	
3932.5	Jan. 7	10.5
3984.5	Feb. 28	10.0

2445 *W Monoc.*—Cont.

Julian	Calendar	Mag.
	1897	
3988.5	Mar. 4	9.4
4008.5	24	10.3
4010.6	26	10.2P
4014.5	30	9.9
4014.6	30	10.4P
4016.5	Apr. 1	10.03_2
4016.6	1	10.4P
4026.5	11	10.53_2
4026.5	11	10.2P
4032.5	17	10.1P
4033.5	18	9.9
4034.6	19	10.2P

2539 *R Canis minoris*.

(Continued from 350.)

	1897	
3931.6	Jan. 6	7.8P
3932.5	7	7.8
3933.5	8	7.37:
3934.5	9	8.09_2
3935.6	10	7.98_2
3936.6	11	7.7P
3943.6	18	7.43_2
3948.6	23	7.7P
3955.6	30	7.54_2
3965.5	Feb. 9	7.86_2
3969.5	13	7.67_2
3970.5	14	8.02_2

2684 *S Canis minoris*.

(Continued from 350.)

Julian	Calendar	Mag.
	1897	
3932.5	Jan. 7	9.1
3933.5	8	9.51_2
3955.5	30	10.35_2
3980.6	Feb. 24	11.3
3984.6	28	11.4
3988.5	Mar. 4	11.6
4008.6	24	11.86_2
4014.5	30	11.97_2
4033.6	Apr. 18	12.39_2
4045.5	30	12]
4050.6	May 5	11.9:
4051.5	6	12.0]

2690 *X Puppis*.

	1897	
3988.6	Mar. 4	8.6P
3991.5	7	8.23
3991.6	7	8.8P
3994.5	10	8.77
3994.6	10	8.8P
4005.5	21	7.5P
4010.6	26	8.3P
4012.5	28	8.56_2
4014.6	30	8.4P
4016.6	Apr. 1	8.5P
4026.5	11	9.1P
4032.5	17	8.4P
4034.5	19	8.4P

2742 *S Geminorum*.

(Continued from 326.)

Julian	Calendar	Mag.
	1897	
3963.6	Jan. 7	11.8
3980.5	Feb. 24	9.6
3983.5	27	10.07_2
3991.5	Mar. 7	9.72_2
3991.5	7	9.5P
3994.6	10	9.4P
3995.5	11	9.21_2
4005.6	21	9.0P
4008.5	24	9.63_2
4010.6	26	9.5P
4012.5	28	10.08_2
4014.6	30	9.7P
4016.5	Apr. 1	9.82_2
4016.6	1	9.7P
4026.5	11	10.1P
4032.5	17	10.9P
4034.6	19	10.8

2780 *T Geminorum*.

(Continued from 377.)

	1896-7	
3905.6	Dec. 11	8.9
3908.6	14	8.68_2
3930.6	Jan. 5	8.75_2
3931.6	6	8.8P
3934.5	9	8.72_2
3936.6	11	8.8P
3948.5	23	8.9P
3955.5	30	9.02_2
3965.5	Feb. 9	8.76_2
3980.5	24	9.23_2
3991.5	Mar. 7	9.72_2

COMPARISON-STARS.

976 *T Arietis*.

Star	DM.	Mag.	*n*
A	+16°355	5.60	0*F*
N	+14°454	8.20	3*M*
P	+16°345	8.09	3
Q	+16°346	8.43	7
R	+16°348	9.06	9
S	+17°440	9.30	12
1*S*	+14°487	8.62	3*M*
T	+15°395	9.28	3*M*
X	+17°439	9.98	5
Z	+16°350	9.74	7

2266 *V Monocerotis*.

1893–1897

Star	DM.	Mag.	*n*
U	−0°1287	5.16	12*M*
1*C*	−1°1242	5.03	16
D	−2°1601	5.73	3
1*E*	−1°1231	6.26	22
2*E*	−3°1413	6.01	3
H	−2°1579	7.77	6
1*H*	−0°1292	6.51	6
I	−1°1198	7.57	8*M*
J	−1°1255	7.77	5
Q	−1°1212	9.11	5*M*

2539 *R Canis minoris*.

1893–1897

Star	DM.	Mag.	*n*
F	+ 9°1539	6.71	10*M*
I	+ 9°1550	7.37	12*M*
L	+10°1429	8.37	33*M*
M	+10°1416	7.75	29*M*
1*N*	+ 9°1549	7.86	7
Q	+10°1414	8.37	2
S	+ 9°1531	8.91	1*M*
2*T*	+10°1422	9.16	17*M*
4*T*	+10°1427	9.28	13*M*
5*T*	+10°1432	9.21	13*M*

2690 *S Puppis*.

Star	S.DM.	Mag.	*n*
I	−20°1999	6.90	2
L	−20°2003	7.82	8
P	−20°2009	8.37	10
1*P*	−19°1908	8.63	6*M*
2*P*	−19°1897	8.48	7*M*
Q	−20°2015	8.32	10
R	−19°1899	8.39	8*M*
S	−19°1898	8.82	4*M*
U	−20°2025	9.07	5
1*U*	−20°1969	9.02	2*M*

MEASURES OF *PROCYON*,

By WILLIAM J. HUSSEY.

The following measures of SCHAEBERLE's companion to *Procyon* have been made with the 36-inch refractor, using a power of 520. Where the seeing is at its best the companion is easily visible; it is of about the 12th magnitude.

	°	″
1897.072	319.23	4.58
.203	320.06	4.77
.206	320.01	4.59
1897.16	319.8	4.65

Lick Observatory, University of California, 1897 *May* 6.

OBSERVATIONS OF COMET 1896 III,

MADE AT THE LICK OBSERVATORY OF THE UNIVERSITY OF CALIFORNIA,

BY WILLIAM J. HUSSEY.

1896 Mt. Hamilton M.T.		✱	No. Comp.	☄ − ✱		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
April 27	8 24 51	1	*d* 7 , 12	+0 39.17	+3 35.5	3 13 42.18	+46 27 54.4	9.783	0.759
	8 32 23	1	3	. . .	+4 12.0	. . .	+46 28 30.9	. .	0.777
30	8 49 23	2	9 , 6	+1 24.30	+6 23.5	2 59 13.14	+52 24 37.7	9.786	0.818
May 2	9 22 44	3	6	. . .	+1 43.4	. . .	+54 47 11.9	. .	0.871
	9 34 13	3	*d*10	−0 4.79	. . .	2 48 46.21	. . .	9.699	. .
6	9 21 13	4	*d* 8 , 10	−0 28.73	+7 31.9	2 24 20.00	+61 7 26.3	9.867	0.895
	9 51 35	5	*d* 8 , 10	+0 9.05	−0 21.5	2 24 11.83	+61 8 51.2	9.570	0.945
7	10 27 27	6	*d* 8 , 11	+0 52.39	+2 21.0	2 17 26.00	+62 15 31.2	9.274	0.933
9	14 44 5	7	*d*10 , 11	+0 25.09	−2 28.0	2 2 43.73	+64 18 30.5	*n*9.627	0.880
	14 40 24	8	*d*10 , 10	−0 19.10	−0 53.1	2 2 35.56	+64 19 28.9	*n*9.662	0.908
13	8 42 0	9	10 , 15	−0 35.24	+3 11.0	1 35 57.40	+67 5 32.9	9.640	0.907
15	10 51 22	10	8 , 6	+3 42.36	−0 51.9	1 20 52.33	+68 17 16.8	*n*9.570	0.913
16	11 13 12	12	13 , 12	−0 52.52	+6 1.5	1 13 31.66	+68 47 28.9	*n*9.738	0.894
18	14 18 13	13	20 , 11	+0 27.07	−5 58.3	0 59 0.25	+69 39 40.5	*n*9.857	0.869
31	10 20 24	14	*d*10 , 10	+0 18.04	−8 11.0	23 27 48.56	+72 34 2.6	*n*0.104	0.746
June 3	10 19 53	15	4	. . .	+7 55.8	. . .	+72 46 33.9	. .	0.682
12	10 26 6	16	*d*10 , 10	[−0 14.99]	−3 11.8	[22 9 0.59]	+72 36 53.6	*n*0.197	0.305
14	11 45 2	18	*d* 4	. . .	−2 23.5	. . .	+72 25 5.2	. .	*n*9.914
	11 57 9	18	*d* 6	+0 10.03	. . .	21 56 20.80	. . .	*n*0.151	. .
16	13 18 12	20	*d* 9 , 12	−1 41.82	−0 31.2	21 43 59.84	+72 9 47.6	*n*9.994	*n*0.538
17	13 2 15	21	*d* 6 , 10	−0 53.35	−1 43.7	21 38 10.53	+72 1 10.5	*n*0.005	*n*0.523
20	14 29 59	23	*d* 8 , 11	+0 21.95	−1 12.3	21 20 17.64	+71 29 28.2	*n*9.510	*n*0.681

Mean Places for 1896.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 13 3.33	−0.32	+46 24 9.2	+ 9.7	Deichmüller, Bonn A.G. Catal. 2775
2	2 58 19.41	−0.57	+52 18 5.3	+ 8.9	Rogers, Cambridge A.G. Catal. 1368
3	2 48 51.75	−0.75	+55 45 20.3	+ 8.2	Krueger, Helsingfors-Gotha A.G. Catal. 2628
4	2 24 50.17	−1.44	+60 59 41.6	+12.8	“ “ “ “ “ 2302
5	2 24 4.20	−1.42	+61 8 59.9	+12.8	“ “ “ “ “ 2293
6	2 16 35.30	−1.69	+62 12 58.6	+11.6	“ “ “ “ “ 2198
7	2 2 20.65	−2.01	+64 20 47.8	+10.7	“ “ “ “ “ 1904
8	2 2 56.66	−2.00	+64 20 11.2	+10.8	“ “ “ “ “ 1924
9	1 36 34.38	−1.74	+67 2 22.0	+ 0.9	Fearnley, Christiania A.G. Catal. 321
10	1 17 11.77	−1.80	+68 18 9.6	− 0.9	10^{M} connected with ✱11
11	1 17 9.99	−1.82	+68 25 59.6	− 0.9	Fearnley, Christiania A.G. Catal. 259
12	1 14 26.00	−1.82	+68 41 28.6	− 1.2	Fearnley, Christiania A.G. Catal. 250
13	0 58 35.04	−1.86	+69 45 41.5	− 2.7	Fearnley, Christiania A.G. Catal. 205
14	23 27 31.40	−0.85	+72 42 22.9	− 9.3	Dorpat A.G. Zones, 72°1107
15	23 9 43.40	−0.45	+72 38 48.2	−10.1	Dorpat A.G. Zones, 72°1092
16	22 9 14.65	+0.93	+72 40 16.1	−10.7	11^{M} connected with ✱17
17	22 10 59.68	+0.93	+72 47 26.7	−10.7	Dorpat A.G. Zones, 72°1022
18	21 56 9.55	+1.22	+72 27 39.2	−10.5	10^{M} connected with ✱19
19	21 59 3.93	+1.22	+72 24 16.0	−10.5	Dorpat A.G. Zones, 72°1011
20	21 45 40.18	+1.49	+72 10 31.5	−10.3	Dorpat A.G. Zones, 72°1090
21	21 39 2.26	+1.62	+72 3 4.3	−10.1	11^{M} connected with ✱22
22	21 41 49.23	+1.61	+72 7 49.3	−10.1	B.B. VI 71°1083
23	21 20 24.69	+2.00	+71 30 49.9	− 9.4	14^{M} connected with ✱24
24	21 21 8.68	+2.00	+71 36 49.7	− 9.4	Dorpat A.G. Zones 71°1062

The large apparent size of this comet and the want of a well defined nucleus made it a difficult object to measure accurately. The above observations, except the last, were made with the 12-inch telescope; the last was made with the 36-inch. *d* indicates that Δα and Δδ were measured directly with the micrometer; in other cases they were obtained by transits. The catalogue indicates a possible correction $\Delta\alpha = -1^{\mathrm{s}}$ for ✱22.

Lick Observatory, University of California, 1897 *May* 5.

THE *GEGENSCHEIN* OR ZODIACAL COUNTERGLOW,

BY E. E. BARNARD.

The following observations of the *Gegenschein* have not previously been published. They are a continuation of the observations printed in former numbers of the *Astronomical Journal*, and have been very carefully made and will, I believe, very closely represent the positions of this very singular object.

It is to be understood, of course, that these are naked-eye observations and are therefore subject to larger personal errors than would be given by almost any kind of instrument. I think, however, considering the largeness and vagueness of the *Gegenschein*, they are singularly accordant, and it is interesting to see how closely an object of this kind can be located with the naked eye.

It will be seen, if these observations are compared with the earlier ones, that experience has very much improved on the first determinations of its position. Indeed I would feel rather confident now that its center can be located ordinarily to within one degree.

In determining the position of the *Gegenschein* it is necessary to study it very carefully for some time and use a considerable amount of judgement, or it will be easy to erroneously locate it by three or four degrees.

I find that the best method for its location is to estimate the distance of its center from the nearest fixed star and then to identify the star by a chart or by an equatorial-pointing. Any attempt to locate its position by tracing its outlines among the stars can only lead to very crude results.

In my previous papers on the *Gegenschein* (*A.J.* VII, 186; XI, 19; XIII, 169) I have called attention to the singular changes this object periodically undergoes. Sometimes it is large and round and at other times very much elongated. On some occasions it has been seen simply as a swelling on a zodiacal band stretching clear across the sky. At times the zodiacal band is seen running from the *Gegenschein* in one direction only — from the eastern end or from the west. This has not been due to the position of the *Gegenschein* with reference to the horizon at the time.

There seems to be a marked periodical change in the form of the *Gegenschein* in the first part of October, when it rather rapidly becomes elliptical or extended along the ecliptic. There seems to be a similar change in the first part of April, though this is not so well established as the October change. I had hoped to settle the important facts in connection with the April change this year but the weather did not permit observations at the critical time.

The *Gegenschein* seems to be as well seen at the Yerkes Observatory as it was at the Lick. Indeed I have been struck with the fact that this object does not require a very transparent sky to show it well, and there have been times when there was a suspicion that it was best seen on a not too transparent sky. It is so easily seen here that nearly every one connected with the observatory has seen it, though they were not familiar with it before.

It will be noticed that the present observations, like the ones previously printed, give a north latitude to the *Gegenschein*, and that there is a tendency to lag in longitude — that is its longitude is not quite 180° greater than that of the sun. These two peculiarities, as I have pointed out in *A.J.* XIII, 171, are doubtless due to atmospheric absorption. I have been waiting to see the observations made by the Harvard College Observatory party at Arequipa, in 1893. Those important observations when published ought to definitely settle the question as to whether the observed north latitude of the *Gegenschein* is due to the effect of atmospheric absorption.

These interesting features will be readily noticed in the following tabulation from my observations of the past fourteen years.

Dates	Latitude	Diff. Long. (λ−☉)	Observations
	°	°	
1883–1887	+0.4	179.4	16
1888–1891	+1.3	179.4	16
1893	+0.5	179.6	22
1894–1897	+0.4	179.9	11

In contrast to these the three observations of 1894 make this difference greater than 180°. It is this rather abnormal condition of 1894 that makes the last value in the above table very closely 180°, while the observations for 1895 and 1897 persistently show that it should be considerably less than 180°.

POSITIONS OF THE *Gegenschein*.

1894		α	δ	λ	β	λ−☉	Δ
	d h m	h m	°	°	°	°	°
Aug.	27 12 55	22 36	− 8.9	337.2	0.0	182.2	+2.2
	30 11 15	22 40	− 7.9	338.5	+0.5	180.7	+0.7
Sept.	4 11 0	22 56	− 6.9	342.5	0.0	180.8	+0.8
1895							
Feb.	27 13 30	10 41	+13.0	156.6	+0.4	177.0	−3.0
Mar.	23 12 30	12 15	− 0.1	183.5	+1.5	180.5	+0.5
Sept.	18 10 30	23 43	− 0.6	355.8	+1.2	179.8	−0.2
1897							
Mar.	24 9 50	12 15	− 2.7	184.4	−1.0	179.6	−0.4
	26 12 30	12 24	− 2.9	186.8	−0.3	179.9	−0.1
April	25 10 10	14 16	−12.4	215.9	+1.0	179.7	−0.3
	26 10 55	14 14	−12.9	215.4	+0.7	178.2	−1.8
	30 10 0	14 37	−15.4	221.7	0.0	180.7	+0.7

In the observations of 1894 and 1895 the times are eight hours slow of Greenwich, and six hours slow in 1897.

For a single observation these give a probable error of ±0°.6 for β and ±0°.9 for λ, while the probable error of the mean is for β ±0°.17 and for λ ±0°.28.

NOTES ON THE *Gegenschein.*

1894 *Aug.* 27. Though there is a dense, misty sky, the *Gegenschein* is seen as a thickening or whitening of this and can be fairly located.

Aug. 30. It does not extend towards *Capricornus.* Round. 15° or 20° in diameter. It is a milky, hazy light, well seen on a not very clear sky.

Sept. 4. It is hazy and indefinite. It does not extend in the direction of *Capricornus.*

1895 *Feb.* 27. Large, roundish and diffused. It covers the entire body of the Lion.

March 23. Pretty distinct, roundish.

Sept. 18. Large, roundish and dense, 15° or more in diameter.

1897 *March* 24. Very large and dense. Roundish and about 20° in diameter.

March 25. Well seen. Very large and roundish: I have never seen it so large as it was last night and is to-night. A very careful estimate made it 25° in diameter to-night. No zodiacal band.

March 26. Fairly conspicuous; cannot say that it is over 20° in diameter. It is large and diffused and so far as I can see is round. Not certain of any zodiacal band, though it was looked for.

March 27. Not certain, but there may be a wide zodiacal band running from the zodiacal light eastward through the place of *Jupiter*, but cannot be anyways certain of it.

March 30. 14^h the *Gegenschein* is seen but the mistiness of the sky makes its location too uncertain. There is no zodiacal band east of it, though the sky to the east is fair.

April 25. Large and very diffused. Elongated along the ecliptic, but bright stars make it difficult.

April 26. The *Gegenschein* is very difficult to-night. It is difficult on account of the milky sky. It is very large and possibly elongated, but not certain. There seems to be a very diffused zodiacal band running from it towards *Leo*, passing 5° north of *Spica.*

It is interesting to compare the probable errors of the determination of the position of the *Gegenschein* from the different sets of observations previously published by me.

The following table was formed by using the means of the different series of observations as reference-points.

PROBABLE ERRORS OF *Gegenschein* OBSERVATIONS.

	In Latitude		In Longitude	
	One obs.	Mean	One obs.	Mean
	°	°	°	°
1883–1887	± 1.5	± 0.38	± 1.4	± 0.34
1888–1891	± 1.3	± 0.30	± 1.4	± 0.34
1893	± 0.3	± 0.06	± 0.7	± 0.14
1894–1897	± 0.6	± 0.17	± 0.9	± 0.28

Yerkes Observatory, Williams Bay, Wisconsin, 1897 *May* 10.

OBSERVATIONS OF COMET 1896 VII,

MADE AT THE LICK OBSERVATORY OF THE UNIVERSITY OF CALIFORNIA,

BY C. D. PERRINE.

1897 Mt. Hamilton M.T.		∗	No. Comp.	☄ — ∗		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Jan. 23	9 51 42	1	*d*10 , 8	+0 26.96	−2 43.7	4 46 1.91	−0 18 53.0	9.212	0.731
23	10 24 11	2	*d*10 , 8	−0 20.81	−3 5.3	4 46 5.67	−0 18 45.7	9.350	0.731
24	9 42 6	3	4	. . . .	+7 21.4	. . . .	−0 14 26.8	. .	0.725
24	10 19 25	3	*d*10 ,	−0 5.22	. . . .	4 49 7.03	. . . .	9.336	. .
25	9 48 40	4	10 . 6	−3 25.62	+1 55.9	4 52 1.88	−0 9 46.1	9.233	0.726
Feb. 9	7 37 53	5	*d*10 , 8	+0 0.98	−2 1.2	5 31 47.68	+1 16 16.3	*n*8.724	0.715
25	8 42 2	7	*d*10 , 8	−0 12.74	+3 36.3	6 8 18.13	+2 54 14.8	9.072	0.698
27	9 1 53	8	*d*10 , 8	+0 2.61	+3 42.9	6 12 36.22	+3 5 30.3	9.218	0.697

Mean Places for 1897.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	4 45 33.12	+1.83	−0 16 12.8	+3.5	½ (Göttingen 1337 + Radcliffe 3, 1145
2	4 46 24.65	+1.83	−0 15 13.9	+3.5	Göttingen 1346
3	4 49 10.42	+1.83	−0 21 51.5	+3.3	Göttingen 1368
4	4 55 25.65	+1.85	−0 11 45.1	+3.1	Göttingen 1414
5	5 31 44.82	+1.88	+1 18 16.0	+1.5	Micrometer-comparison with ∗6
6	5 30 25.91	+1.87	+1 15 19.8	+1.5	Boss, Albany, A.G. 1813
7	6 8 29.00	+1.87	+2 50 38.8	−0.3	Boss, Albany, A.G. 2073
8	6 12 31.73	+1.88	+3 1 47.8	−0.4	Boss, Albany, A.G. 2111

d indicates that the $\Delta\alpha$ was measured directly with the micrometer. The observations of January 23 and 24 were made with the 12-inch equatorial; those of January 25, February 9, 25, 27, were made with the 36-inch equatorial. An extended period of bad weather prevented more and later observations. Boss's value of the proper motion of ∗ 7 as given in the A.G. Catalogue has been applied.

Mt. Hamilton, 1897 *May* 10.

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ON THE LATITUDE AND VARIATION OF LATITUDE AT THE U.S. NAVAL OBSERVATORY, WASHINGTON, D.C.,

By Prof. WM. HARKNESS, U.S.N., Astronomical Director, and Assistant Astronomer GEORGE A. HILL.

The following observations for variation of latitude were made at the U.S. Naval Observatory with the prime-vertical transit instrument of 77 inches focus and 4.86 inches clear aperture, magnifying 102 diameters, and with a meridian instrument of 30 inches focus, and 2.55 inches clear aperture, magnifying 61 diameters, which can be used either as a transit instrument or as a zenith-telescope. As the telescopes of both these instruments have apertures sufficient to show *α Lyrae* in the day time, the plan of work was to observe that star for variation of latitude at every possible culmination throughout the year, and to observe *μ Andromedae, θ Aurigae, α Canum Venaticorum* and *γ Bootis* near the times of their maximum aberration in order to disentangle the latter constant from the latitude-variation.

For *α Lyrae*, the method of procedure was to observe it on the eastern vertical with the prime-vertical transit, then on the meridian with the zenith-telescope, and finally on the western vertical with the prime-vertical transit. In that way the declination of the star was determined at every possible culmination, both with the prime-vertical instrument, and by measuring its double zenith-distance with the zenith-telescope, and thus a very complete check is obtained on the work of both instruments.

Dealing first with the prime-vertical transit observations, let

φ = assumed latitude of the instrument,
φ' = observed latitude of the instrument,
δ = catalogue-declination of the star,
δ' = observed declination of the star,
h' = observed hour-angle of the star when on the prime-vertical.

Then the observations can be reduced so as to give either the latitude of the instrument from the assumed declinations of the stars, or the declinations of the stars from the assumed latitude of the instrument. For many reasons the latter plan seems preferable, and accordingly the reductions have been effected by means of Struve's modification of the formula

$$\tan\delta' = \tan\varphi \cos h' \qquad (1)$$

But for our present purpose we have to determine the variations of the latitude of the instrument from the corrected declinations of the stars, and to that end we remark that whenever the observed δ' comes out greater than the true δ, it indicates that the assumed φ is greater than the observed φ'. Consequently, we must have

$$\varphi' = \varphi - d\varphi \qquad (2)$$

and if we put

$$\delta + d\delta = \delta' \qquad (3)$$

then from (1), by regarding φ and δ' as variable and differentiating, we get

$$d\varphi = \frac{\cos^2\varphi \tan\varphi}{\cos^2\delta' \tan\delta'}\, d\delta' = \frac{\sin 2\varphi}{\sin 2\delta'}\,(\delta'-\delta) \qquad (4)$$

and the substitution of that value in (2) gives

$$\varphi' = \varphi + \frac{\sin 2\varphi}{\sin 2\delta'}\,(\delta-\delta') \qquad (5)$$

As five stars were observed, let the quantities pertaining to each be distinguished, respectively, by the subscript numerals 1, 2, 3, 4, 5. Then each star will furnish an observation-equation of the form (5), but in general the star-places will be affected by systematic errors, and in order to eliminate them each declination will require a small correction, which we will designate by the symbol $\Delta'\delta$. The observation-equations from the several stars may then be written (6)

$$\varphi' = \varphi + \frac{\sin 2\varphi}{\sin 2\delta_1}\,(\delta_1-\delta_1') \quad ; \quad \varphi' = \varphi + \frac{\sin 2\varphi}{\sin 2\delta_3}\,(\Delta'\delta_3+\delta_3-\delta_3')$$

$$\varphi' = \varphi + \frac{\sin 2\varphi}{\sin 2\delta_2}\,(\Delta'\delta_2+\delta_2-\delta_2') \quad ; \quad \varphi' = \varphi + \frac{\sin 2\varphi}{\sin 2\delta_4}\,(\Delta'\delta_4+\delta_4-\delta_4')$$

&c., &c., &c.

Whence, by subtracting the first equation from each of the others

$$(7)\quad \left\{ \begin{aligned} \Delta'\delta_2 &= \frac{\sin 2\delta_2}{\sin 2\delta_1}(\delta_1-\delta_1') - (\delta_2-\delta_2') \\ \Delta'\delta_3 &= \frac{\sin 2\delta_3}{\sin 2\delta_1}(\delta_1-\delta_1') - (\delta_3-\delta_3') \\ \Delta'\delta_4 &= \frac{\sin 2\delta_4}{\sin 2\delta_1}(\delta_1-\delta_1') - (\delta_4-\delta_4') \\ &\text{\&c.,} \quad \text{\&c.,} \quad \text{\&c.} \end{aligned} \right.$$

If we regard the catalogue-declination of the star 1 as definitive, then $+\Delta'\delta_2, +\Delta'\delta_3, +\Delta'\delta_4, +\Delta'\delta_5,$ are respectively the corrections to the catalogue-declinations of the stars 2, 3, 4, 5; but if we regard the catalogue-declinations of the stars 2, 3, 4, 5, as definitive, then $-\Delta'\delta_2, -\Delta'\delta_3, -\Delta'\delta_4, -\Delta'\delta_5,$ are respectively the corrections given by these stars to the catalogue-declination of the star 1. As none of the catalogue-declinations are really definitive, it will probably be best to take the weighted mean of them all. Putting p_1 for the weight of δ_1, p_2 for the weight of δ_2, and so on; the correction to δ_1 will then be

$$(8)\quad \frac{p_2\Delta'\delta_2+p_3\Delta'\delta_3+p_4\Delta'\delta_4+p_5\Delta'\delta_5}{p_1+p_2+p_3+p_4+p_5} = A$$

And if we use the symbol δ^0 to represent the adjusted declinations, we shall have

$$(9)\quad \left\{ \begin{aligned} \delta_1^0 &= \delta_1 - A &, \quad \delta_4^0 &= \delta_4 - A + \Delta'\delta_4 \\ \delta_2^0 &= \delta_2 - A + \Delta'\delta_2 &, \quad \delta_5^0 &= \delta_5 - A + \Delta'\delta_5 \\ \delta_3^0 &= \delta_3 - A + \Delta'\delta_3 \end{aligned} \right.$$

Finally, by substituting δ^0 for δ in (5), we obtain

$$(10)\quad \varphi' = \varphi + \frac{\sin 2\varphi}{\sin 2\delta}\left[(\delta-\delta')-A+\Delta'\delta\right]$$

which is the expression to be employed in computing the instantaneous latitudes from the individual observations. If now we put $\varphi + C$ for the true latitude, and $\Delta\Phi$ for its variation, then

$$(11)\quad \varphi'-\varphi = \Delta\Phi + C$$

and (10) gives

$$(12)\quad \Delta\Phi + C = \frac{\sin 2\varphi}{\sin 2\delta}\left[(\delta-\delta')+\Delta'\delta-A\right] = \frac{\sin 2\varphi}{\sin 2\delta}(\delta^0-\delta')$$

In reducing the prime-vertical observations made between 1893 July 24 and 1896 June 30, it was assumed that

$$\varphi = +38°\ 55'\ 14''.70$$

and for the catalogue-places of the stars observed, Professor LEWIS BOSS's mean declinations, as printed in the *American Ephemeris and Nautical Almanac*, were adopted. They are given below for the year 1893.0, together with the differential coefficients necessary for reducing them to any other year t. The subscripts appended to the δ's are those used to indicate the several stars in formulas (6) to (9), and throughout this paper.

α Lyrae,

$$\delta_1 = +38°\ 41'\ 2''.88 + 3''.178\,(t-1893) + 0''.001\,(t-1893)^2$$

μ Andromedae,

$$\delta_2 = +37°\ 55'\ 8''.34 + 19''.610\,(t-1893) + 0''.000\,(t-1893)^2$$

θ Aurigae,

$$\delta_3 = +37°\ 12'\ 16''.40 + 0''.580\,(t-1893) - 0''.005\,(t-1893)^2$$

α Canum Venaticorum,

$$\delta_4 = +38°\ 53'\ 46''.39 - 19''.512\,(t-1893) + 0''.001\,(t-1893)^2$$

γ Bootis,

$$\delta_5 = +38°\ 46'\ 34''.77 - 15''.863\,(t-1893) + 0''.000\,(t-1893)^2$$

The individual observations having been reduced in accordance with STRUVE's method, the resulting apparent values of δ' were converted into mean values by the application of the reduction from apparent to mean place, and then by subtracting these mean values from the respective catalogue-places of the several stars, the values of $(\delta-\delta')$ were formed. All of them are collected and arranged in chronological order in Table I*, where the second column gives the mean astronomical dates of the observations; the third column shows the stars observed, by means of the numerals 1, 2, 3, 4, 5, which indicate respectively *α Lyrae*, *μ Andromedae*, *θ Aurigae*, *α Canum Venaticorum*, and *γ Bootis*, the letter *R* being appended for reflection-observations; and the fourth column contains the observed values of $(\delta-\delta')$.

The next step was to reduce the declinations of the several stars to a homogenous system, and that was effected as follows:

1st. The values of $(\delta-\delta')$ for *α Lyrae*, which are designated $(\delta_1-\delta_1')$, were separated into groups extending over about a week, and the means, both of the $(\delta_1-\delta_1')$s and of their dates, were formed and collected in Table II.* These data were then plotted and a curve was drawn through them from which the values of $(\delta_1-\delta_1')$ could be accurately read off for any date.

2d. For each of the stars, except *α Lyrae*, a table was formed giving the value of $(\delta-\delta')$ resulting from each observation, together with the simultaneous value of $(\delta_1-\delta_1')$ taken from the curve whose construction has just been explained. These values of $(\delta-\delta')$ and $(\delta_1-\delta_1')$ were summed separately for each star, and the results are given in the columns of Table A, headed respectively $\Sigma(\delta-\delta')$ and $\Sigma(\delta_1-\delta_1')$. Next, these sums were each divided by the number of observations entering into it, and from the resulting mean values, which are given in the columns of Table A headed respectively $(\delta-\delta')$ and $(\delta_1-\delta_1')$, the values of $\Delta'\delta$ were obtained by means of formula (7). Finally, with the weights p, which are those attributed by Professor BOSS to his values of the declinations, the value of A was found by means of formula (8), and the corrected declinations of the several stars were obtained through formula (9).

---

* Omitted.

The quantities in Table A apply to all the observations, except those made between 1894 March 12 and Sept. 24. During that period the prime-vertical transit instrument was affected by a systematic error whose origin still remains a mystery, but it seems to have been connected with the level-readings. Fortunately the existence of this error was detected very soon after its first appearance, and in order to provide for its elimination the observations of *α Lyrae* were frequently made by reflecting the star from a basin of mercury. The results, collected from Table I, are given in Table B, where the columns headed *R* and *D* contain respectively the values of $(\delta-\delta')$ for the reflection and direct observations. The dates refer strictly to the reflection-observations, and the corresponding values given for the direct observations are generally the mean of those occurring immediately before and immediately after the reflection-observation.

TABLE A. — QUANTITIES REQUIRED FOR CORRECTING THE OBSERVATIONS MADE WITH THE PRIME-VERTICAL TRANSIT INSTRUMENT.

Name of Star	Limiting Dates	No. Obsns.	$\Sigma(\delta_1-\delta_1')$	$\Sigma(\delta-\delta')$	$\delta_1-\delta_1'$	$\delta-\delta'$	$\frac{\sin 2\delta_n}{\sin 2\delta_1}$	$\Delta'\delta$	p	$p\,\Delta'\delta$
			″	″	″	″		″		″
α Lyrae	1893.563 to 1896.498	287	. .	. .	. .	. .	. .	0.000	26	0.000
μ Andromedae	1893.835 to 1896.002	69	−10.86	+17.48	−0.157	+0.253	0.9938	−0.409	7	−2.863
θ Aurigae	1893.744 to 1896.271	91	−44.45	−25.92	−0.489	−0.285	0.9871	−0.198	3	−0.594
α Canum Venat.	1894.835 to 1896.470	70	−27.61	−44.23	−0.394	−0.632	1.0015	+0.237	20	+4.740
γ Bootis	1894.422 to 1894.554	21	−35.24	−47.07	−1.678	−2.241	1.0006	+0.562	. .	. .
								Sums	56	+1.283

Name of Star	A	$\Delta'\delta-A$	Corrected Declination 1893.0	$\frac{\sin 2\varphi}{\sin 2\delta}$
	″	″	° ′ ″	
α Lyrae	+0.023	−0.023	+38 41 2.86	1.0018
μ Andromedae	+0.023	−0.432	+37 55 7.91	1.0081
θ Aurigae	+0.023	−0.221	+37 12 16.18	1.0149
α Canum Venat.	+0.023	+0.214	+38 53 46.60	1.0003
γ Bootis	+0.023	+0.539	+38 46 35.31	1.0012

TABLE B. — COMPARISON OF THE DIRECT AND REFLECTION OBSERVATIONS OF *α Lyrae.*

Date	*R*	*D*	*R—D*	½ (*R—D*)	Date	*R*	*D*	*R—D*	½ (*R—D*)
1894	″	″	″	″	1894	″	″	″	″
May 3.7	+0.84	−1.88	+2.72	+1.36	June 20.5	+0.60	−1.70	+2.30	+ 1.15
7.7	0.31	1.88	2.19	1.10	23.5	0.05	1.19	1.24	0.62
9.7	0.53	1.94	2.47	1.24	July 3.5	0.63	1.34	1.97	0.98
12.7	0.32	1.90	2.22	1.11	13.5	0.51	1.59	2.10	1.05
25.7	0.04	1.74	1.78	0.89	20.5	0.80	1.95	2.75	1.38
June 8.6	0.68	2.38	3.06	1.53	20.8	0.81	1.96	2.77	1.38
10.6	1.06	2.26	3.32	1.66	Sept. 20.2	0.40	1.91	2.31	1.16
14.6	+0.42	−2.24	+2.66	+1.33	23.2	+0.72	−1.96	+2.68	+ 1.34
								Sum	+19.28
								Mean	+1.205

Doubtless it is best to assume that the true declination of any star is the mean of the declinations found for it from direct and reflection observations, and in that case we shall have from (9) for a direct observation

$$\delta^{\circ} = \delta + \Delta'\delta - A + \tfrac{1}{2}(R-D) \tag{13}$$

and for a reflection-observation

$$\delta^{0} = \delta + \Delta'\delta - A - \tfrac{1}{2}(R-D) \tag{14}$$

By substituting these values in (12), and putting at the same time

$$\frac{\sin 2\varphi}{\sin 2\delta} = 1 + m$$

we get

$$\Delta\Phi + C = (1+m)[(\delta-\delta') + \Delta'\delta - A \pm \tfrac{1}{2}(R-D)] \tag{15}$$

$$= (\delta-\delta') + m(\delta-\delta') + (1+m)[\Delta'\delta - A \pm \tfrac{1}{2}(R-D)]$$

where the double sign is to be taken positive for a direct observation, and negative for a reflection one. As m is very small, if we write

$$K = m(\delta-\delta') + (1+m)[\Delta'\delta - A \pm \tfrac{1}{2}(R-D)] \tag{16}$$

K will be nearly constant for each star, and after tabulating it to the argument $(\delta-\delta')$, the variation of the latitude can be found by a simple addition, in accordance with the formula

$$\Delta\Phi + C = (\delta-\delta') + K \tag{17}$$

Table C has been computed by means of formula (16), with the values of m, $\Delta'\delta - A$, and $\frac{1}{2}(R - D)$ given in Tables A and B. It contains all the values of K which are necessary for reducing the entire series of prime-vertical observations; Part I being for stars observed when the instrument was working normally, viz., during the periods from 1893 July 24.4 to 1894 February 10.9, and from 1894 September 25.7 to 1896 June 30.5; and Part II being for stars observed when the instrument was working abnormally, viz., during the period from 1894 March 12.8, to September 24.2. In order to avoid interpolation, the table is so arranged that the limits within which each value of K applies are shown by the values of $(\delta - \delta')$ between which it is placed. For example, in the case of *μ Andromedae*, for all values of $(\delta - \delta')$ between $+1''.30$ and $+0''.06$ the value of K is $-0''.430$.

TABLE C. — VALUES OF K, FOR REDUCING OBSERVATIONS MADE WITH THE PRIME-VERTICAL TRANSIT INSTRUMENT.

Name of Star	Part I, General		Part II, Special	
	δ—δ′	K	δ—δ′	K
	″	″	″	″
α Lyrae (Direct) 1	+ 4.44 − 1.11 − 6.67	−0.02 −0.03	+6.06 +0.50 −5.06	+1.19 +1.18
α Lyrae (Reflected)	. .	. .	+2.89 −2.67	−1.23
μ Andromedae 2	+ 1.30 + 0.06 − 1.17	−0.43 −0.44		
θ Aurigae 3	+ 1.29 + 0.62 − 0.05 − 0.72 − 1.39	−0.21 −0.22 −0.23 −0.24	−0.92 −1.59 −2.26	+0.98 +0.97
α Can. Venaticorum 4	+ 3.00 −30.33	+0.21		
γ Bootis 5	. . . .	. . . .	+7.42 −0.92 −9.25	+1.75 +1.74

In accordance with formula (17), the quantities in the columns of Table 1, headed $\Delta\Phi + C$, were obtained from those in the columns headed $(\delta - \delta')$ by adding to the latter the proper values of K, taken from Table C with the argument $(\delta - \delta')$.

It yet remains to consider the observations of *α Lyrae* made by Talcott's method during the period extending from 1894 Nov. 22.1 to 1896 June 30.5. The object to be attained was the accurate measurement of the double zenith-distance of the star, and the meridian instrument employed was provided with 5 right-ascension webs at intervals of about 15 seconds of time, and 3 zenith-distance micrometer-webs at intervals of about 17 minutes of arc. The right-ascension webs were numbered I to V, and the micrometer-webs were designated respectively A, B, C; the latter being farthest from the micrometer-head. The method of procedure was to set the zenith-distance level so that the optical axis of the telescope pointed to the zenith, and then to make the level-readings, reversal, and micrometer-pointings precisely as would have been done in observing a pair of stars. The star entered the field near either web A or web C, according as the clamp was west or east, and in either case one micrometer-bisection was made with web A, at right-ascension web I, and the other with web C, at right-ascension web V. By making the bisections at these right-ascension webs an interval of one minute was obtained for reversing the telescope and making the second pointing, and by using micrometer-webs A and C the movement of the micrometer-screw necessary for measuring the double zenith-distance of about 28.5 minutes was reduced to about 5 revolutions. The observations on successive days were begun with the clamp alternately east and west.

The reduction of the observations was effected by the formula (18)

$$\delta' = q - \tfrac{1}{2}R(M_A - M_C) + \tfrac{1}{4}D[(N+S)_w - (N+S)_e] - r - \Delta\delta$$

where δ' is the observed declination of the star; q the assumed latitude of the instrument; M_A and M_C the micrometer-readings upon the star at zenith-distance webs A and C; R the value of one revolution of the micrometer-screw, expressed in seconds of arc; N and S the readings of the north and south ends of the level-bubble, the subscripts e and w indicating which readings were made with clamp east and which with clamp west; D the value of one division of the level-scale, expressed in seconds of arc; r the refraction, and $\Delta\delta$ the correction for curvature of the path of the star between web I or V, and the central web which marked the meridian.

In connection with formula (18), two points require special notice, viz.: — 1st, as the meridian instrument was 406.7 feet = $4''.020$ south of the prime-vertical transit instrument, we must have Latitude of Meridian Instrument = (Latitude of Prime-Vertical Transit Instrument) $-4''.02$. 2nd, owing to the magnitude of the double zenith-distance of *α Lyrae*, it was necessary to determine the value of the micrometer-screw with more than usual accuracy, and that was satisfactorily accomplished by measuring the differences of the zenith-distances of the stars *b*, *c*, *d*, *η*, *f* and *h Tauri*, on 18 different nights.

The numerical values of the constants in formula (18) are as follows:

$$q = +38^\circ\ 55'\ 14''.70 - 4''.02 = +38^\circ\ 55'\ 10''.68$$

$$R = 68''.4554 \pm 0''.0028 \qquad r = 0''.22$$

$$D = 1''.23 \qquad \Delta\delta = 0''.20$$

and their substitution in the formula reduces it to the convenient expression

$$(19)\qquad \begin{aligned}\delta = 38°\,55'\,10''.26 &-34''.2277\,(M_A - M_C)\\ &+0''.3075\,[(N+S)_w-(N+S)_e]\end{aligned}$$

As already explained, it was intended that at every possible culmination *α Lyrae* should be observed both with the prime-vertical transit instrument and with the zenith-telescope, and as the values of $\Delta\Phi + C$ which result respectively from these two methods of observation should evidently be identical, they provide a means of eliminating any small errors which may exist in the constants of the zenith-telescope. To that end let ζ be the zenith-distance found by Talcott's method, and suppose it to be affected by the small error $d\zeta$, so that the true zenith-distance is $\zeta + d\zeta$. Then we shall have the two equations

$$(20)\qquad \varphi = \delta' + \zeta$$

$$(21)\qquad \varphi' = \delta^0 + (\zeta+d\zeta) = \delta + \Delta'\delta - \Delta + (\zeta+d\zeta)$$

whence

$$(22)\qquad \varphi' - \varphi = (\delta-\delta')_z + \Delta'\delta - \Delta + d\zeta = \Delta\Phi + C$$

And by equating this to the value of $\Delta\Phi + C$ given in (12), we get

$$(23)\qquad \Delta'\delta - \Delta + d\zeta = \frac{\sin 2\varphi}{\sin 2\delta}\,[(\delta-\delta')_v + \Delta'\delta - \Delta] - (\delta-\delta')_z$$

where the subscripts v and z indicate the values of $(\delta-\delta')$ which have been obtained respectively from observations made with the prime-vertical instrument and with the zenith-telescope.

All the zenith-telescope observations of *α Lyrae* are contained in Table VII*, and by comparing that with Table I*, 191 cases were found in which $(\delta-\delta')$ was determined both with the prime-vertical transit instrument and with the zenith-telescope, either at the same culmination, or under circumstances which permitted the observed values to be safely interpolated to the same culmination. All these simultaneous values are collected in Table VIII*, and by the application of formula (23) to the data therein contained, we derive the numbers exhibited in Table D. It is worthy of note that the value found for $d\zeta$ barely exceeds that part of the probable error of $(\delta-\delta')$ which arises from the uncertainty in the value of a revolution of the zenith-distance micrometer-screw; viz.,

$$\pm 0''.0028 \times 12.5 \text{ rev.} = \pm 0''.0350.$$

All the values of $\Delta\Phi + C$ which result from the zenith-telescope observations of *α Lyrae* are given in the last column of Table VII, and have been derived from the corresponding values of $(\delta-\delta')$, given in the third column, by adding to the latter the value of $\Delta'\delta - \Delta + d\zeta$ found in Table D, viz., $+0''.02$.

TABLE D. — VALUES OF $\Delta'\delta - \Delta + d\zeta$, AND OF $d\zeta$, FOR REDUCING OBSERVATIONS MADE WITH THE ZENITH-TELESCOPE.

	Prime-Vertical	Zenith-Telescope
No. of observations	191	191
$\Sigma(\delta-\delta')$	$-94''.79$	$-102''.76$
$(\delta-\delta')$	$-$ 0.4963	$-$ 0.5380
$\Delta'\delta-\Delta$	$-$ 0.0229	. . .
$(\delta-\delta')+\Delta'\delta-\Delta$	$-$ 0.5192	. . .
$\sin 2\varphi\,/\sin 2\delta$	1.0018	. . .
$\frac{\sin 2\varphi}{\sin 2\delta}[(\delta-\delta')+\Delta'\delta-\Delta]$	. . .	$-$ 0.5201
$\Delta'\delta-\Delta+d\zeta$	. . .	+ 0.0179
$d\zeta$	. . .	+ 0.0408

Tables I and VII contain all the individual observed values of $\Delta\Phi + C$, and the next step was to form semi-monthly means from them. In doing so the first half of each month was regarded as consisting of 15.0 days, except in the case of February where it was allotted only 14.0 days; and in every case the remainder of the month was regarded as constituting the second half. The semi-monthly means, both of the values of $\Delta\Phi + C$ and of the dates to which they correspond, are given in Table IX, where the prime-vertical observations are kept separate from those made with the zenith-telescope, partly to show the results given by the two perfectly independent methods, and partly because of their different weights, arising from the great difference in size between the telescopes of the two instruments. The quantities in the columns headed "Weighted Means" are to be regarded as the final observed results, and in forming them from the quantities in the columns headed "Prime-Vertical Observations" and "Zenith-Telescope Observations," a zenith-telescope observation has been given only half the weight of a prime-vertical observation.

Dr. S. C. CHANDLER thinks that the latitude-variation is composed of two terms, whose periods are respectively $[428.6+55\sin(t-2{,}402{,}327)\,0°.015]$ days, and one tropical year*. If so, we may write with sufficient accuracy

$$(24)\qquad \begin{aligned}\Delta\Phi + C = &- r_1\cos[(t-T_1)\,0°.841122]\\ &- r_2\cos(\odot - G) + C\end{aligned}$$

where $\odot$ is the sun's longitude at the date t; and then by the method of least squares we may determine C, r_1, r_2, T_1 and G from the observed values of $\Delta\Phi + C$. This, however, would involve an amount of labor which is scarcely justified by the limited period over which the observations have extended, and in view of the fact that six of the 428-day periods are almost exactly equal to seven tropical years it will probably be better to wait until seven years' observations have accumulated, and then by means of the harmonic analysis it will be possible to obtain satisfactory values of all the constants with very little labor.

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* Omitted.

* *Ast. Jour.*, 1895, vol. 15, p. 193, and 1897, vol. 17, p. 63.

Meanwhile it is desirable to get some idea of the value of C, and the first step in that direction will be to deduce from the observations a uniformly distributed system of values of $\Delta\Phi + C$. To that end the weighted mean values of $\Delta\Phi + C$, given in Table IX, were plotted upon squared paper, a smooth curve was drawn through them, and from it the required values were read off at intervals of 0.05 of a tropical year = 18.262 days. The values thus obtained are given in Table E, and in order to cover a period of three complete years, the observations have been extended to a date about one month later than in the other tables. The total number of equidistant values thus obtained is 60, and their sum is $-28''.98$. We therefore have from (24)

$$\Delta\Phi + C = \frac{-28''.98}{60} = -\frac{r_1\Sigma\cos(t-T_1)\,0^\circ.841}{60} - \frac{r_2\Sigma\cos(\odot - G)}{60} + C \tag{25}$$

As these observations extend over 36 months, they embrace 2.56 periods of the 428-day term, and exactly 3 periods of the annual term. Consequently the effect of the latter disappears completely from the mean of the series, and although we cannot rigorously evaluate the former for want of knowledge of T_1, nevertheless the maximum limit of its influence is easily estimated. To that end we remark that for 0.560 of the 428-day period, the term $\Sigma\cos(t-T_1)\,0^\circ.841$ requires the summation of 13 cosines at intervals of 18.262 days multiplied by $0^\circ.84112 = 15^\circ.361$, and if we begin at either 90° or 270° the series will amount to 7.367, which is approximately its maximum value. Therefore (25) gives

$$-0''.483 = C \pm 0.123\,r_1 \tag{26}$$

and as the value of r_1 can scarcely exceed $0''.18$, the limit of the uncertainty which it can produce will be about $\pm 0''.022$, and the total probable error of C may fairly be estimated at not more than $\pm 0''.10$.

By subtracting the value of C given in (26) from the values of $\Delta\Phi + C$ given in Table E, we obtain the observed values of the variation of latitude given in Table F.

TABLE E. — Equidistant Values of $\Delta\Phi + C$, read from the Smoothed Curve.

Date	1893	1894	1895	1896
″	″	″	″	″
0.00	. . .	−0.11	−0.45	−0.25
.05	. . .	.16	.54	.32
.10	. . .	.21	.65	.40
.15	. . .	.28	.70	.46
.20	. . .	.40	.69	.52
.25	. . .	.52	.60	.52
.30	. . .	.60	.53	.45
.35	. . .	.66	.53	.38
.40	. . .	.70	.60	.35
.45	. . .	.70	.70	.36
.50	. . .	.70	.76	.40
.55	. . .	.71	.80	−0.50
.60	−0.60	.72	.80	. . .
.65	.45	.70	.80	. . .
.70	.30	.69	.75	. . .
.75	.28	.64	.62	. . .
.80	.11	.58	.43	. . .
.85	.08	.51	.27	. . .
.90	.08	.45	.20	. . .
0.95	−0.10	−0.41	−0.20	. . .
Sums	−2.00	−10.45	−11.62	−4.91

TABLE F.—Observed Values of the Variation of the Latitude at the U.S. Naval Observatory.

Date	1893	1894	1895	1896
″	″	″	″	″
0.00	. . .	+0.37	+0.03	+0.23
.05	. . .	.32	− .06	.16
.10	. . .	.27	.17	.08
.15	. . .	.20	.22	+0.02
.20	. . .	+0.08	.21	−0.04
.25	. . .	−0.04	.12	−0.04
.30	. . .	.12	.05	+0.03
.35	. . .	.18	.05	.10
.40	. . .	.22	.12	.13
.45	. . .	.22	.22	.12
.50	. . .	.22	.28	+0.08
.55	. . .	.23	.32	−0.02
.60	−0.12	.24	.32	. . .
.65	+0.03	.22	.32	. . .
.70	.18	.21	.27	. . .
.75	.20	.16	−0.14	. . .
.80	.37	.10	+0.05	. . .
.85	.40	−0.03	.21	. . .
.90	.40	+0.03	.28	. . .
0.95	+0.38	+0.07	+0.28	. . .

.N.B. The plus sign indicates that the observed latitude was numerically greater than the mean latitude.

The value of C given in (26) rests upon 620 observations with the prime-vertical transit instrument, and 248 observations with the zenith-telescope, and from it we obtain the results in the opposite column.

In conclusion, it seems proper to state that while the Astronomical Director is responsible for the plan of the work and for the mathematical theory employed in the foregoing discussion, the observations themselves were all made and reduced by Assistant Astronomer Hill.

Results.

Assumed latitude of the prime-vertical transit instrument,	+38° 55′ 14″.700	
Observed correction,	−0″.483	±0″.10
Corrected latitude of the prime-vertical transit instrument,	+38° 55′ 14″.217	±0″.10
Reduction to center Clock Room,	−0″.518	
Latitude of center of Clock Room,	+38° 55′ 13″.699	±0″.10

TABLE IX.—Semi-monthly Means of the Observed Values of ΔΦ + C.

P. V. Observations			Z. T. Observations			Weighted Mean		
Mean Date	No. Obs.	Δφ	Mean Date	No. Obs.	Δφ	Mean Date	No. Obs.	Δφ
1893		″			″	1893		″
July 27.4	4	−0.64	. . .	. .	. .	July 27.4	4	−0.64
Aug. 30.3	1	0.22	. . .	. .	. .	Aug. 30.3	1	0.22
Sept. 5.9	5	0.53	. . .	. .	. .	Sept. 5.9	5	0.53
24.5	11	−0.17	. . .	. .	. .	24.5	11	−0.17
Oct. 8.4	15	+0.01	. . .	. .	. .	Oct. 8.4	15	+0.01
22.5	11	−0.04	. . .	. .	. .	22.5	11	−0.04
Nov. 8.4	12	+0.26	. . .	. .	. .	Nov. 8.4	12	+0.26
23.2	18	0.04	. . .	. .	. .	23.2	18	0.04
Dec. 7.3	11	0.01	. . .	. .	. .	Dec. 7.3	11	0.01
22.7	6	+0.23	. . .	. .	. .	22.7	6	+0.23
1894						1894		
Jan. 12.9	3	−0.42	. . .	. .	. .	Jan. 12.9	3	−0.42
27.9	3	−0.09	. . .	. .	. .	27.9	3	−0.09
Feb. 5.9	3	+0.01	. . .	. .	. .	Feb. 5.9	3	+0.01
Mar. 13.8	2	−0.88	. . .	. .	. .	Mar. 13.8	2	−0.88
22.0	3	−1.18	. . .	. .	. .	22.0	3	−1.18
Apr. 8.3	2	+0.31	. . .	. .	. .	Apr. 8.3	2	+0.31
24.9	8	−0.41	. . .	. .	. .	24.9	8	−0.41
May 7.9	9	0.71	. . .	. .	. .	May 7.9	9	0.71
17.6	4	0.78	. . .	. .	. .	17.6	4	0.78
June 8.8	10	0.83	. . .	. .	. .	June 8.8	10	0.83
22.6	17	0.40	. . .	. .	. .	22.6	17	0.40
July 9.3	16	0.58	. . .	. .	. .	July 9.3	16	0.58
20.4	10	0.45	. . .	. .	. .	20.4	10	0.45
Aug. 31.3	1	0.93	. . .	. .	. .	Aug. 31.3	1	0.93
Sept. 6.3	5	0.57	. . .	. .	. .	Sept. 6.3	5	0.57
23.2	11	0.78	. . .	. .	. .	23.2	11	0.78
Oct. 8.5	11	0.54	. . .	. .	. .	Oct. 8.5	11	0.54
20.7	12	0.56	. . .	. .	. .	20.7	12	0.56
Nov. 6.3	11	0.46	. . .	. .	. .	Nov. 6.3	11	0.46
22.6	25	0.44	Nov. 25.1	7	−0.93	22.8	32	0.50
Dec. 8.5	21	0.54	Dec. 8.7	5	0.69	Dec. 8.5	26	0.56
21.9	21	0.28	21.9	8	0.27	21.9	29	0.28
1895			1895			1895		
Jan. 8.1	10	0.58	Jan. 9.9	3	0.65	Jan. 8.4	13	0.59
			24.3	7	0.52	24.3	7	0.52
Feb. 9.5	5	0.81	Feb. 8.3	2	1.00	Feb. 9.5	7	0.84
21.9	12	0.69	21.4	7	0.23	21.9	19	0.59
Mar. 7.0	8	0.68	Mar. 7.1	3	0.70	Mar. 7.0	11	0.69
23.4	16	0.70	23.8	8	0.52	23.4	24	0.67
Apr. 8.8	6	0.62	Apr. 8.8	3	0.33	Apr. 8.8	9	0.56
19.4	6	0.42	19.4	6	0.77	19.4	12	0.52
May 9.0	3	0.57	May 9.0	3	0.41	May 9.0	6	0.52
27.4	12	0 84	25.1	11	0.56	26.7	23	0.75
June 4.9	9	0.84	June 5.0	6	0.87	June 4.9	15	0.85
20.5	3	0.72	20.3	8	0.58	20.5	11	0.64
			July 6.7	6	0.18	July 6.7	6	0.18
Aug. 24.4	9	0.69	Aug. 24.4	10	0.86	Aug. 24.4	19	0.75
Sept. 7.4	11	0.70	Sept. 7.4	11	0.69	Sept. 7.4	22	0.70
23.5	12	0.57	23.6	9	0.17	23.5	21	0.46
Oct. 6.7	15	0.74	Oct. 6.8	8	0.88	Oct. 6.7	23	0.77
22.8	21	0.58	22.7	14	0.62	22.8	35	0.58
Nov. 7.4	11	0.14	Nov. 5.9	7	0.39	Nov. 7.4	18	0.20
21.9	8	0.12	21.8	7	0.38	21.9	15	0.21
Dec. 10.1	16	0.25	Dec. 8.7	6	0.69	Dec. 9.6	22	0.32
22.2	11	0.11	23.8	6	0.24	22.5	17	0.15
1896			1896			1896		
Jan. 7.1	6	0.17	Jan. 7.1	6	0.42	Jan. 7.1	12	0.26
24.6	7	−0.31	23.9	6	−0.36	24.4	13	−0.33

P. V. Observations			Z. T. Observations			Weighted Mean		
Mean Date	No. Obs.	Δφ	Mean Date	No. Obs.	Δφ	Mean Date	No. Obs.	Δφ
1896		″	1896		″	1896		″
Feb. 10.9	8	−0.36	Feb. 10.9	4	−0.48	Feb. 10.9	12	−0.37
19.3	10	0.54	20.4	3	0.09	19.5	13	0.51
Mar. 8.0	16	0.47	Mar. 8.0	7	0.30	Mar. 8.0	23	0.44
22.2	9	0.45	23.2	5	0.69	22.4	14	0.50
Apr. 8.0	8	0.25	Apr. 9.2	5	0.63	Apr. 8.3	13	0.34
24.0	8	0.64	22.7	6	0.88	23.7	14	0.71
May 9.1	9	0.43	May 8.4	6	0.09	May 8.6	15	0.35
25.0	10	0.43	25.0	5	0.14	25.0	15	0.37
June 8.0	9	0.30	June 8.4	5	0.42	June 8.1	14	0.33
22.4	8	0.45	24.1	9	0.46	22.5	17	0.45
July 8.5	4	0.38	July 8.5	6	0.49	July 8.5	10	0.43
22.4	3	0.38	22.5	4	0.88	22.5	7	0.58
Aug. 8.0	11	0.61	Aug. 8.0	11	0.68	Aug. 8.0	22	0.63
24.1	9	0.43	24.0	9	0.19	24.0	18	0.35
Sept. 7.7	8	0.54	Sept. 6.8	6	0.80	Sept. 7.3	14	0.61
24.2	4	0.70	24.3	3	0.29	24.2	7	0.59
Oct. 8.7	7	−0.89	Oct. 9.3	5	−0.36	Oct. 9.0	12	−0.74

OBSERVATIONS OF COMETS 1896 V, 1896 VII AND *f* 1896,

MADE AT THE U.S. NAVAL OBSERVATORY,

BY PROF. STIMSON J. BROWN.

[Communicated by Prof. WM. HARKNESS, U.S.N., Astronomical Director.]

1896-7 Washington M.T.	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log *p*Δ for α	log *p*Δ for δ
			COMET 1896 V.					
Nov. 25 7h 9m.9	2	3 , 3	−0m 3s.83	−0′ 54″.2	21h 6m 18s.13	−12° 37′ 46″.2	9.4459	0.8177
			COMET *f* 1896.					
Nov. 25 6 10.8	3	8 , 4	+0 1.76	+5 31.0	19 56 8.53	+ 9 19 26.2	9.4699	0.6619
			COMET 1896 VII.					
1897 Feb. 4 9 19.8	4	18 , 5	+0 33.26	−1 2.4	5 19 8.14	+ 0 45 3.3	9.0915	0.7355
23 8 20.1	5	6 , 5	−0 8.59	−0 46.44	6 3 41.33	+ 2 41 48.5	8.8211	0.7159

Mean Places for 1896.0 and 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	21h 4m 40s.37	+3s.23	−12° 42′ 16″.4	+ 9″.4	Schjellerup 8524
2	21 6 18.73	+3.23	−12 36 56.6	+ 9.1	From *1. Δα +1m 38s.36, Δδ +5′ 19″.8
3	19 56 4.42	+2.35	+ 9 13 44.3	+10.9	Lalande 38208
4	5 18 32.93	+1.89	+ 0 46 1.6	+ 4.1	Bond's H.C. Zones 157–8. No. 283
5	6 3 48.05	+1.87	+ 2 42 34.9	0.0	From *6. Δα −37s.60; Δδ −10′ 46″.8
6	6 4 25.65	+1.87	+ 2 53 21.7	0.0	Boss. Albany A.G. Zone 20409

February 23d the comet was very faint and difficult to observe. It has not been seen here since, although search has been made for it.

THIRD SATELLITE OF *JUPITER*.

Mr. PERCIVAL LOWELL telegraphs May 27: "DOUGLASS finds *Ganymede* rotates in 7d 5h.1 ± 1h.2."

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A NEW DETERMINATION OF THE PRECESSIONAL MOTION,

By SIMON NEWCOMB.

§1. Preliminary.

At the Conference on a system of fundamental stars to be adopted for international use, held at Paris in May 1896, I was requested to make a new determination of the constant of precession. This work being completed, it seems important to publish the result at the earliest moment, without waiting for the official publication.

It was advisable that the provisional value to be corrected should be so taken that the correction should be as small as possible. I chose as most likely to satisfy this condition the values of the precessional motions found in my *Elements and Constants*, pp. 196–201. Taking the century of 36524.22 days as the unit of time, the value of the fundamental quantity which enters into the work, which I have called the *Precessional Constant*, is

$$P = 5489''.78$$

The corresponding values of the centennial precessional motions are, in terms of ϵ, the obliquity, and λ, the luni-solar precession, for 1850,

General precession,	$P \cos\epsilon - \lambda \cos\epsilon$	$= 5023''.71$
Luni-solar precession,	$P \cos\epsilon$	$= 5036.02$
Precession in R.A.,	$P \cos^2\epsilon - \lambda$	$= 4606.36$
Precession in Decl.,	$P \cos\epsilon \sin\epsilon$	$= 2004.79$

The equinox to which the new value should conform was that of the adopted standard system, known as N_1, and identical with that employed in the *American Ephemeris* from 1881 to 1899. For the declinations a new fundamental system was constructed.

For reasons which I need not detail, it was deemed best to found the result mainly on stars of Auwers–Bradley. The systematic errors incident to a comparison of any other catalogue with modern results would outweigh any probable errors arising from the diversity of proper motions of the Bradley stars. The use of this material offered the great additional advantage that the proper motions of the stars had all been computed by Auwers, and were therefore at hand to serve as a basis of the work. They were, however, first reduced to the new systems, both of right-ascension and declination. The systematic corrections were not inconsiderable, especially in right-ascension, as the reduction for equinox, and the reduction from Struve's value of precession to the system N_1, both had the same sign. Incidentally I have also made use of a comparison of Lalande's catalogue with modern results in right-ascension.

The most troublesome feature of the discussion is the parallactic motion of the stars arising from the solar motion. The difficulty thus introduced arises from the fact that this motion is a function of the distance of the star, an unknown quantity for which no criterion can be applied. Doubtless the best criterion would be the magnitude of the proper motion itself, to which the parallactic motion, in a general way, has been found by Stumpe to be proportional. But the application of this criterion would have implied a knowledge of the proper motions, which themselves depend on the adopted magnitude of the precession. There would therefore be danger of systematic error in introducing this criterion. It was therefore necessary to introduce the very rude criterion of the magnitudes, as, in fact, has been done by other investigators.

Another difficulty arises from the fact that the proper motions of the stars do not follow the normal or exponential law of error on which the method of least-squares and the practice of taking means are based. As compared with the normal distribution of accidental quantities the facts show, in the case of the stars, a very great excess of small and of large proper motions above the normal numbers. This is a very natural consequence of the unequal distances of the stars. It was therefore necessary to adopt the system of excluding stars with large proper motions. The fact of the great number of stars having very small proper motions led me to set much narrower limits of exclusion than had heretofore been usual. About one-fifth of all the stars were excluded by the limits adopted.

Instead of a system of absolute exclusion, it would have been theoretically preferable to have adopted a system of weights diminishing with the magnitude of the proper motion, converging towards zero as the motion increases. But a comparison of the statistical distribution showed that no material advantage would thus have been gained, nor would the result have been appreciably affected. The easier method of omitting entirely stars outside of certain limits was therefore adopted.

These two difficulties in the treatment led me to adopt as great a variety of methods of treatment as possible. Moreover, the right-ascensions and declinations were first considered separately. The number of separate and independent results was thus made as great as possible, in order to form an estimate of the certainty of any final result that might be obtained from their combination. By most of the methods separate preliminary results were obtained from groups of stars of the different magnitudes. In making this division into groups, the magnitudes were taken as given in Auwers Bradley. The stars there found were divided into six groups. The first contained all the brightest stars up to magnitude 2.9. By the adopted mode of treatment, it was necessary to combine the first and second magnitudes, because those of the first magnitude were too few in number to be treated separately. The next group comprised the stars from magnitude 3.0 to 3.9; the next from magnitude 4.0 to 4.9; etc., up to magnitude 6.9. All of magnitude 7.0 or higher were collected into a single group, and designated as magnitude 7.

§ 2. The Statistical Method.

When the mean of a series of quantities is to be found, there is one definition of that mean which is independent of the distribution of the quantities in magnitude. We may call it the *statistical mean*. It is defined as a quantity such that the number of positive and negative deviations of the given quantities from it are equal. If the total number of quantities is odd, this mean will be one of the quantities; if even, it will be an indeterminate quantity lying between two central quantities. The indeterminateness may be avoided by taking half the sum of these quantities. A discussion of the advantages and limitations of this method would be interesting, but cannot be undertaken in the present paper.

I have applied the method only to the right-ascensions. Were there no systematic differences of proper motion in different parts of the heavens, or were the stars equally distributed around the circle of right-ascension, we should adopt as the statistical precession a quantity such that the number of positive and negative proper motions should be equal. But there is a marked inequality in the distribution which, combined with the parallactic motion, would lead to an erroneous result by taking the stars as a whole. What I have done, therefore, has been to divide the circle of right-ascension into four quadrants, and to find, in each quadrant, a certain proper motion μ_0 such that the number of proper motions greater and less than μ_0 should be equal. The equality is not, however, absolute. In determining μ_0 it was assumed that the centennial proper motions within the second of arc containing it were equally distributed through that second. The quadrants started from 0^h. It would have been better to have started them with $3^h\,30^m$, in order that the right-ascension of the solar apex should have fallen in the middle of a quadrant instead of nearly between two. But I do not conceive that any materially different result would thus have been reached.

The values of μ_0 thus found for the four quadrants, and for the different magnitudes are as follows:

Quadrant	I	II	III	IV	Mean	Wt.
Mag. 1–2	+3″.0	−1″.0	−2″.6	+6″.5	+1″.5	0.1
3	+2.7	−5.1	−3.0	+3.4	−0.5	0.5
4	+1.93	−1.45	−0.87	+2.11	+0.43	1.8
5	+2.05	−0.90	−2.20	+2.25	+0.30	6.3
6	+2.00	−1.25	−1.94	+1.70	+0.13	12.0
7	+2.8	−1.4	−0.3	+1.6	+0.68	3.5
Combined	+2.11	−1.25	−1.73	+2.08	+0.30	

A combined result from the stars of all magnitudes may be obtained in two ways. One consists in taking a weighted mean of the separate results from the six groups of stars. Another result is obtained by regarding the stars of the brighter magnitudes as fractions in the count of proper motions. The values of the μ_0 resulting from this weighted count are given in the bottom line of the preceding table. The two results for the observed excess of the mean centennial precession in R.A. for all the stars are

Weighted mean,	+0″.27
Weighted count,	+0.30
Adopted result,	0.285

Assuming an equal distribution of stars this excess is the value of $100\,\Delta m$ multiplied by the mean value of $\cos\delta$ from the pole to, say, −20° of declination, or by 0.84. We therefore have, by the statistical method, using R.A.'s only,

$$100\,\Delta m = \frac{0''.285}{0''.84} = +0''.34$$

$$\Delta p_1 = +0''.37$$

§ 3. Method by Individual Stars.

The reduced proper motions μ and μ' of each individual star give equations between the corrections Δp_1 to the luni-solar precession the distance, ρ of the star, and the coordinates $X\,Y\,Z$ of parallactic motion of the following form:

$$a\Delta p_1 + \sin\alpha\,\frac{X}{\rho} - \cos\alpha\,\frac{Y}{\rho} = \mu\cos\delta$$

$$b\Delta p_1 + \cos\alpha\,\sin\delta\,\frac{X}{\rho} + \sin\alpha\,\sin\delta\,\frac{Y}{\rho} - \cos\delta\,\frac{Z}{\rho} = \mu'$$

The second method employed consists in solving all the equations of condition thus formed, the solution being first made separately for each magnitude, regarding ρ as the same for all stars of a group. Afterward, a pair of equations were formed from all the magnitudes combined, assuming a relation between the values of ρ. It may be here remarked that in the second equation we might as well have put at once

$$\Delta n = \Delta p_1 \sin\epsilon = 0.40\,\Delta p_1$$

In this way the 6 groups give us 12 sets of normal equations, 6 from the right-ascensions and 6 from the declinations. Each of these 12 sets admit of an independent solution. In combining them, however, account must be taken of the fact that the parallactic motion is greater in the case of the brighter stars. A study of the subject showed that the reciprocals of the parallactic motions, and therefore the values of ρ, were probably inversely proportional to the following system of factors; that is to say, the parallactic motion for any one magnitude being multiplied by this factor would reduce it to the parallactic motion for stars of magnitude 5.0 to 5.9 which, for brevity, I call magnitude 5 simply.

Magnitudes,	1–2	3	4	5	6	7
Factors,	0.4	0.6	0.8	1.0	1.2	1.4

These numbers were conceived to be also inversely proportional to the probable errors of dispersion of the proper motions in the case of the stars of each magnitude. Their squares would therefore express the weight to which a star of a given magnitude would be entitled. The coordinates of solar motion for magnitude 5 derived from a solution of the combined normal equations thus formed were,

$$\begin{aligned} X &= +0''.203 \\ Y &= -2.745 \\ Z &= +1.666 \end{aligned}$$

It must be remembered that this is derived only from stars of small proper motion, which are not those best adapted to the special determination of the solar motion. But since the latter can only be determined relatively to other stars, this is the value we should use in connection with that particular group of stars from which we infer the magnitude of the precession. The results of substituting this value of the solar motion in the separate normal equations in Δp are next shown.

Separate results for the precession from stars of various magnitudes.

	R.A.	Decl.	Combined
Mag. 1–2	$\Delta p_1 = +2''.16$	$\Delta p_1 = -0''.10$	$\Delta p_1 = +1''.92$
3	+0.19	−1.05	+0.09
4	+0.16	+1.70	+0.19
5	+0.21	+1.16	+0.31
6	+0.22	+1.35	+0.34
7+	+0.41	+1.30	+0.53
All	+0.24	+1.34	+0.36

I have also utilized the works of Auwers, Boss and Dreyer to derive a correction of the precessional constant from Dreyer's comparison of the Lalande-zones with Schjellerup, and from Boss's comparison of Lalande with his Albany zone. I can give only the results, which are

Lalande–Schjellerup, Δp_1 =	+0″.71
Lalande–Boss,	+0.57
Mean	+0.64

§4. Method by Zones and Regions.

The foregoing method is subject to the objection that, in many cases, several neighboring stars are found to have a nearly equal proper motion, and are therefore so combined in a system that they should be considered only as a single star. I therefore adopted another method founded on the supposition that all stars in any one region of the heavens might possibly be affected by a common proper motion. So far as this is true it involves the hypothesis that the stars within the region are at equal distances, and therefore should have equal weight. The diversity of proper motions for magnitudes 4.0 and upwards is so much less than in the case of the higher stars that, in the application of the method, I depended solely on these stars, rejecting all of the third and brighter magnitudes. In the case of the right-ascensions, the sphere was divided into zones of 15° wide in right-ascension, counting from the equator in each direction. But the few stars south of −30° were included in the zone −15° to −30°. Then, within each zone, the mean proper motion was found within the limits of each two hours of right-ascension. A value of the precessional motion could therefore be derived separately from each zone, since the parallactic motion in the direction of right-ascension is independent of the declination. Each proper motion thus found was assumed to correspond to the central point of the region, and equations of condition similar to those already given were constructed. Three systems of weights were employed: one in which the weights were taken as proportional to the number of stars, another in which they were all considered as equal, and a third in which the motions in each trapezium were supposed to have a common element equal to one-third the average motion of the stars within the region.

In the solution by the last two methods, the parallactic motion was taken as already determined by the second method, because the motion in question is nearly eliminated from the precession when this method is employed.

In the case of the declinations, the southern zone extended from the equator to −20°, while the northern ones were taken 15° wide. The results are

a:—from Right-Ascensions.

Weights as number of stars, Δp_1 =	+0″.20
Weights equal,	+0.28
Weights adjusted,	+0.20

The divergence of the first result from that from individual stars ($0''.24 - 0''.20 = 0''.04$) arises mainly from the omission of the two first magnitudes in the last result, and from the different system of combination of results.

β: — from Declinations.

-20° to 0°	$100\ \Delta n =$	$+0''.47$	Wt. =	108
0 to +15		+0.60		96
+15 to +30		+0.48		105
+30 to +45		+0.29		71
+45 to +60		+0.33		64
+60 to +75		+0.55		49
+75 to +90		−0.02		30
Mean		+0.44		Σ = 523

Whence, $\Delta p_1 = 2.5\ \Delta n = +1''.10$.

The preceding results show that the declinations give a much larger value of the precession than do the right-ascensions. From the latter we have, by different methods of treatment, results ranging from

$$\Delta p_1 = +0''.20 \text{ to } +0''.34$$

while the declinations give $1''.10$ to $1''.34$. Yet another feature is the diversity of values found from the stars of different right-ascensions. It is true that no result can be derived from stars in any other one point of the circle of right-ascension than the apex and anti-apex of the solar motion, because everywhere else the precession will be affected by the parallactic motion. But it still remains true that the parallactic motion should be eliminated from any two opposite hours of right-ascension, provided that stars of equal magnitude are at equal distances in the two directions, in other words, that the mean absolute magnitude of the stars is the same all around the sphere. The following table shows the diversity in question when the precessions are determined in right-ascension using the definitive values of the parallactic motions, and then combining opposite pairs of constants, so taken that the solar apex ($A = 18^h.5$) shall fall in the central meridian of an octant.

Octant	Δp_1	Octants	Δp_1	
I, $18^h.5$	$+0''.96$	I–V,	$+0''.67$	Wt. = 5
II, 21.5	+0.47	II–VI,	+0.27	3
III, 0.5	−0.08	III–VII,	−0.31	2
IV, 3.5	+0.38	IV–VIII,	+0.05	3
V, 6.5	+0.39	Weighted mean	+0.28	
VI, 9.5	+0.07			
VII, 12.5	−0.54			
VIII, 15.5	−0.28			

These discordances cannot be eliminated by changing the parallactic motion as a whole.

§5. FOURTH METHOD: BY ELIMINATING THE PARALLACTIC MOTION.

The presence of the uncertain quantity ρ in the equations of §3 being a disturbing element in the problem, I have tried the method of eliminating it from each pair of equations given by a single star. By assuming a position (A, D) of the solar apex we derive an equation of the form

$$\Pi\, \Delta p_1 = a'\mu' - b'\mu \cos\delta = \tau \cos \Delta$$

where Π, a' and b' are functions of A, D, and the position of the star; τ the motion on a great circle in Sun-way longitude, and Δ the Sun-way latitude of the star.

$$a' = \cos D \sin(\alpha - A)$$
$$b' = \cos D \sin\delta \cos(\alpha - A) - \sin D \cos\delta$$

This amounts to the same thing as determining the precession from the apparent motion of a star in a direction at right-angles to that of the solar apex, in other words, to substitute for the motion in right-ascension and declination a motion in Sun-way longitude. This term may be applied to a longitude reckoned around the solar apex as a pole. This method has been proposed and, in fact, actually applied by KAPTEYN, but I am not aware that he has published any definitive result.

A question arises in applying the method owing to the fact that, taken rigorously, the weight of the result necessarily vanishes in the case of a star situated either around the apex or near the pole of the ecliptic. But in the case of a star near the solar apex there is no need of applying the method, because the parallactic motion vanishes at the apex. It is also to be remarked that on the meridian and anti-meridian of the apex the motion in Sun-way longitude coincides with that in right-ascension.

I have therefore applied the method by dividing the heavens into four regions; two of these regions are lunes of two hours of right-ascension each, including the meridian and anti-meridian of the solar apex, and the other two are zones about 45° in breadth around the Sun-way equator. The following table shows the results from stars of the third and higher magnitudes. I call the regions between the lunes the vernal and autumnal regions, according as they include the vernal or the autumnal equinox.

Vernal Region.

	No. Stars	Σ Π	$\Sigma\, \tau \cos \Delta$	Δp_1
Mag. 3	18	15.5	$15''.4$	$+0''.99$
4	64	55.4	46.0	+0.89
5	149	128.3	56.5	+0.41
6	231	195.7	189.3	+0.97
7	56	48.6	56.2	+1.16
Total,	518	546.4	474.2	+0.87

Autumnal Region.

	No. Stars	Σ Π	$\Sigma\, \tau \cos \Delta$	Δp_1
Mag. 3	19	16.1	$-13''.7$	$-0''.85$
4	44	37.7	+ 0.1	0.00
5	120	100.1	+24.0	+0.24
6	214	182.2	+ 3.9	+0.02
7	47	40.5	− 3.4	−0.08
Total,	441	267.7	+18.1	+0.07

The combined result is obtained by multiplying the numbers ΣH and $\Sigma \tau \cos \Delta$ for the different magnitudes by the factors already derived, which, in the present case, are simply the squares of the assumed orders of distance, 0.6, 0.8, etc. The products are then added.

The following comparison of results in the different regions from the motion in right-ascension and from that in Sun-way longitude may be of interest.

Region	Mot. in R.A.	Mot. in S.W. Long.	Wt.
	″	″	
Meridian of solar apex,	+0.96	+1.14	1
Vernal region,	+0.30	+0.87	2
Anti-meridian of solar apex,	+0.40	+0.81	1
Autumnal region,	−0.21	+0.07	2

In the two sets of results the regions, and therefore the stars, are not absolutely identical. The results from the right-ascensions include all the stars. It will be seen that the discordance between the results from those stars which are and those which are not affected by parallactic motion is materially diminished, but not wholly removed, by eliminating the parallactic motion.

The mean result of the latter method is

$$\Delta p_1 = +0''.64$$

§ 6. RESULTS.

All the results for the precessional movement from the R.A.'s are to be considered as requiring the addition of an unknown constant $1.09\,\Delta E'$, this symbol representing the common correction which may be required to the assumed centennial motion of the standard stars in R.A., or to the system N_1. The evidence points to a positive value of this quantity, which may possibly amount to $0''.5$, but nothing definite can be determined. A fraction of the same correction will be required for the results in Sun-way longitude. Subject to this correction we have the following separate results for the correction Δp_1:

A. *From Right-Ascensions alone.*

BRADLEY stars:	Solutions of equations, $\Delta p_1 =$	$+0''.20$
	Statistical method,	$+0.37$
	Mean,	$+0.29 + 1.09\,\Delta E'$
LALANDE stars,		$+0.64$ "

I think the result from the LALANDE stars is entitled to one-fifth the weight of that of the BRADLEY stars. We therefore have, for the definitive correction of the value N_0 of the luni-solar centennial precession, as derived from R.A.'s, the expression

$$\Delta p_1 = +0''.35 + 1.09\,\Delta E'$$

B. *From Declinations alone.*

I accept the result of §4,

$$\Delta p_1 = 2.5\,\Delta n = +1''.10$$

C. *By Eliminating the Parallactic Motion.*

$$\Delta p_1 = +0''.64$$

We now reach the very difficult problem how to combine these three values, the extremes of which diverge by $0''.75$, a quantity much greater than the sum of their probable errors. The latter cannot even be inferred from any set of residuals, but only from a judgement of the probable amount and effect of the systematic errors from all causes. In the case of the right-ascensions the large systematic variations with the right-ascensions seem to indicate that, making abstraction of the equinoctial correction, we should still have to assign a probable error of $\pm 0''.15$. To this we must add the probable error arising from variation of personal equation with magnitude, which differs from one observer to another. If we ignore any recent results for the magnitude $\Delta E'$, we must suppose this correction to vanish, but must still include its probable value as a probable error. This I should estimate as lying between $\pm 0''.25$ and $\pm 0''.30$.

In the case of the declinations we may estimate the probable error of the correction to $100n$ as lying between $\pm 0''.12$ and $\pm 0''.16$. This would give a probable error of p between $\pm 0''.30$ and $\pm 0''.40$.

By combining the two results, A and B, assigning weights corresponding to the estimated probable errors, we may obtain values of Δp_1 varying between $+0''.60$ and $+0''.80$. It is to be remarked, however, that the results from the right-ascensions can be reconciled with those from the declinations by assigning a suitable value to the unknown correction $\Delta E'$. The Greenwich observations of the sun during the sixty years 1836–1895, may now be considered to supply the best homogeneous data at our command for determining this quantity. A rude computation of the results indicates for $\Delta E'$ a value of about $+0''.5$; the comparison of the right-ascensions of *Mercury* on both sides of the sun with the fixed stars indicates a correction of $+1''.0$. These results should not be taken by themselves, but in connection with the value zero, which followed from a general discussion of all the observations of the sun up to 1870 on which the equinox N_1 depends. Altogether I do not think that the correction which will ultimately be found is likely to exceed $+0''.3$ or $+0''.4$, but that it may well amount to one of these quantities.

We may therefore anticipate that when it is determined and applied, the resulting value of the precessional constant will be rather more likely to exceed $0''.80$ than to fall short of it. The question now arises whether it is allowable to anticipate such a correction.

The system N_1 having been adopted for international use, and being quite likely to be continued for some years to come, there is a certain amount of reason in making the precessional motion correspond to it, notwithstanding the discordance in the declinations. But when a value of the precessional motion is once adopted, it is desirable to continue it as long as possible without change, probably for half a century, possibly through the whole of the twentieth century if no strongly marked correction should be found. An anticipation of the value which would probably best suit the future astronomy therefore seems desirable.

Taking all these considerations together, I have concluded that the best value to adopt is

$$\Delta p_1 = +0''.80$$

This amounts to substantially the same thing as increasing the value N_0 of the precessional constant P by the factor .00016, which gives,

$$P = 5490''.66$$

The following is a comparison of the Struve–Peters precessional motions for a century, and for the epoch 1850, with those thus arising from this value of P.

The luni-solar precession is a term used ambiguously. Sometimes this precession is counted on a fixed ecliptic taken once for all time; that of 1750 or 1800. As I have used it, it is referred to the fixed ecliptic of the date.

	Struve–Peters ″	New. ″	Diff. ″
General Precession,	5025.24	5024.53	−0.71
Luni-solar Precession,	5038.23	5036.84	−1.39
Value of 100 m,	4607.65	4607.11	−0.54
Value of 100 n,	2005.64	2005.11	−0.53

For convenient reference I give the following values of the annual motions for intervals of twenty-five years, showing the numbers to be used in reductions of the mean place of the fixed stars from one epoch to another, when we use the preceding value of the precessional constant, and the secular motion of the ecliptic as deduced from the masses of the planets employed in my tables of the Sun. The numbers serving for the rigorous trigonometric reduction of star places from one epoch to another are added.

Values of the Annual Precessional Motions from 1725 *to* 2000.

	Precession							
	General ″	Luni-Solar ″	m ″	m_s s	n ″	log n	n_s	log n_s
1725	50.2175	50.3622	46.0362	3.06908	20.0618	1.302369	1.33745	0.126278
1750	50.2230	50.3634	46.0432	3.06955	20.0596	1.302323	1.33731	0.126232
1775	50.2286	50.3647	46.0501	3.07001	20.0575	1.302277	1.33717	0.126186
1800	50.2341	50.3659	46.0571	3.07048	20.0554	1.302231	1.33703	0.126140
1825	50.2397	50.3671	46.0641	3.07094	20.0532	1.302185	1.33689	0.126094
1850	50.2453	50.3684	46.0711	3.07141	20.0511	1.302139	1.33674	0.126048
1875	50.2508	50.3696	46.0780	3.07187	20.0490	1.302092	1.33660	0.126001
1900	50.2564	50.3708	46.0850	3.07234	20.0468	1.302046	1.33646	0.125955
1925	50.2619	50.3721	46.0920	3.07280	20.0447	1.302000	1.33632	0.125909
1950	50.2675	50.3733	46.0990	3.07327	20.0426	1.301954	1.33617	0.125863
1975	50.2731	50.3745	46.1060	3.07373	20.0404	1.301908	1.33603	0.125817
2000	50.2786	50.3758	46.1129	3.07420	20.0383	1.301862	1.33589	0.125771

Quantities expressing the relative positions of the equator and equinox at any two epochs, for use in the trigonometric reduction of mean places of the fixed stars from one epoch to another.

We consider the quadrangle formed by the poles of the equator and ecliptic at two different epochs. One of these epochs we call the zero-epoch. It is supposed to be that for which the position of a star is given, and to which the various quantities are in the first place referred. The other epoch is considered to be a variable one. We represent the respective poles of the ecliptic and equator by the symbols E and P, those which refer to the zero-epoch being called E_0 and P_0.

We join the points E_0 and P so as to divide the quadrangle into two spherical triangles E_0P_0P and E_0PE. We represent the parts of these triangles which enter into the theory as follows:

$\epsilon_0 = E_0P_0$, or the obliquity of the zero-equator to the zero-ecliptic.

$\epsilon_1 = E_0P$, or the obliquity of the actual equator to the zero-equator.

$\epsilon = EP$, or the obliquity of the actual mean equator to the actual ecliptic.

$\vartheta = PP_0$, the distance between the poles or the obliquity of the actual to the zero-equator.

$\Psi =$ Angle P_0E_0P, or the luni-solar precession upon the zero-ecliptic.

$90° - \zeta_0 =$ Angle E_0P_0P.

$90° - \zeta =$ Angle E_0PP_0.

$\lambda =$ Angle E_0PE, the planetary precession on the equator, or the arc of the equator intercepted between the two ecliptics.

$z = \zeta - \lambda$.

The formulas embodying the application of the preceding quantities to the reduction of the fixed stars differ from those of Bessel, used by Chauvenet, in that the epoch for which the poles E_0 and P_0 is supposed to be given is the same for which the position of the star is given. In the other theory the zero-epoch is a constant for the whole theory, so that three different positions of each pole enter into the theory. This change involves a slight change of notation, which seems necessary in order to avoid confusion.

The notation here adopted differs from that in the concluding pages of "*Elements and Constants*" only in that I have put ζ_0 for ζ_1.

The reduction in question involves three constants, θ, ζ_0, and z, of which the use is as follows. We put

α_0, δ_0, the coordinates of the star as given for an epoch t_0 which I call the zero-epoch.

α, δ, the coordinates as reduced to an epoch t by precession only.

We then compute

$$\begin{aligned} a_0 &= \alpha_0 + \zeta_0 \\ p &= \sin\theta\,(\tan\delta_0 + \tan\tfrac{1}{2}\theta\cos a_0) \\ \tan(a - a_0) &= \frac{p\sin a_0}{1 - p\cos a_0} \\ \tan\tfrac{1}{2}(\delta - \delta_0) &= \frac{\cos\frac{1}{2}(a + a_0)}{\cos\frac{1}{2}(a - a_0)}\tan\tfrac{1}{2}\theta \\ \alpha &= a + z \end{aligned}$$

As defined by these equations the constants θ, ζ_0, and z are functions of t_0 and t, and can be most conveniently expressed as functions of t_0 and $t - t_0$, because then they vary very slowly with t_0. Their values for any pair of epochs between 1600 and 2100 may be found from the following expressions, which are given for three values of the zero-epoch t_0. We put

$$\tau = \frac{t - t_0}{250}$$

t_0				
1600	$\zeta_0 =$	$5750''.17\,\tau$	$+1''.90\,\tau^2$	$+0''.28\,\tau^3$
1850		5758.88	+1.89	+0.28
2100		5767.61	+1.88	+0.28

t_0				
1600	$z =$	$5750''.17\,\tau$	$+6''.82\,\tau^2$	$+0''.30\,\tau^3$
1850		5758.88	+6.83	+0.30
2100		5767.61	+6.84	+0.30
1600	$\theta =$	$5018.10\,\tau$	$-2.66\,\tau^2$	$-0.64\,\tau^3$
1850		5012.77	−2.66	−0.65
2100		5007.44	−2.67	−0.65

As an example of the use of these expressions let us suppose the epoch for which α and δ are given, to be 1875. By interpolation of coefficients we find the following expression for ζ_0, z and θ:

1875	$\zeta_0 =$	$5759''.75\,\tau$	$+1''.89\,\tau^2$	$+0''.28\,\tau^3$
	$z =$	5759.75	+6.83	+0.30
	$\theta =$	5012.24	−2.66	−0.65

Were the epoch t 1900 we should put $\tau = 0.10$, which would give

$$\begin{aligned} \zeta_0 &= 575''.994 \\ z &= 576.043 \\ \theta &= 501.196 \end{aligned}$$

as the constants for reduction from 1875 to 1900.

A check on these values is afforded by computing the values for reduction from 1900 to 1875. We do this by taking 1900 for t_0 and putting $\tau = -0.10$. If we put the values of ζ, z and θ thus found in parentheses we should have

$$\begin{aligned} (\zeta_0) + z &= 0 \\ (z) + \zeta_0 &= 0 \\ (\theta) + \theta &= 0 \end{aligned}$$

MAXIMA AND MINIMA OF LONG-PERIOD VARIABLES,

BY J. A. PARKHURST.

103. *T Andromedae.*

The last minimum of this star occurred 1896 Nov. 24, at $12^{\rm M}.6$. The date is deduced from 12 observations, beginning 1896 Aug. 3, and ending 1897 Feb. 13. There is at least one observation in each month, and the star was always visible in good seeing; the faintest observed magnitude being $12^{\rm M}.7$, Nov. 26. I had made an effort to observe the previous minimum, and secured 11 comparisons from 1895 Nov. 1 to 1896 Feb. 8, after which the star was lost in the twilight. In this interval it had decreased from $9^{\rm M}$ to $12^{\rm M}.3$. These observed points fell very close to the curve for the above minimum, making it very probable that the minimum occurred 1896 March 1 $\pm 5^{\rm d}$, at $12^{\rm M}.6$. The interval between these minima, 268 days, agrees very well with YENDELL's period. The value of $M - m$ is about 110 days.

294. *W Cassiopeae.*

My continuous watch on this star was broken by a gap from 1897 Feb. 2 to May 3, nevertheless the minimum, 1897 Feb. 28, at $11^{\rm M}.9$, is fairly well determined by comparison with the curve for the previous minimum. The star fell slowly from $9^{\rm M}.7$ 1896 Nov. 12, to the minimum, and rose from $11^{\rm M}.8$ to $11^{\rm M}.3$ during May. I have 9 observations.

678. *U Persei.*

I have 18 observations between 1896 Sept. 7 and 1897 Feb. 2. The star rose slowly, but quite regularly, from $9^{\rm M}.5$ to a crest of $7^{\rm M}.4$ on Nov. 22, and after a slight decrease, there was a second crest, of the same brightness, Dec. 9. However, as the second crest depends on a single comparison in poor seeing, I should prefer the maximum given by the general curve through all the points, giving Dec. 1 as the date, at $7^{\rm M}.4$. At the last observation the brightness was $8^{\rm M}.5$.

1805. *V Orionis.*

A maximum, at $8^{\rm M}.6$, is indicated for 1896 Dec. 31, by 6 observations, beginning 1896 Nov. 12, and ending 1897 Jan. 28. The star on the first and last dates was $10^{\rm M}.3$ and $9^{\rm M}.7$, respectively.

2258. *V Aurigae.*

My observations, 8 in number, began 1896 Nov. 26, and ended 1897 May 21, with a break from Feb. 1 to May 3. A minimum at $11^M.7$ is indicated for Feb. 1, with an uncertainty of perhaps two weeks. This date is borne out by a comparison of the curve with those of the last three minima.

3890. *W Leonis.*

Three morning observations of this star were secured for the purpose of testing roughly H. M. PARKHURST's elements, as given in the Second Catalogue. I found it 1896 Nov. 12, $10^M.4$; Dec. 2, $10^M.8$; 1897 Jan. 7, $11^M.8$. The magnitudes are photometric, using H. M. PARKHURST's values for the comparison-stars. A maximum is suggested for November, about a month earlier than called for by the above elements.

7085. *RT Cygni.*

Eight observations, beginning 1896 Nov. 26, and ending 1897 Feb. 2, yield a maximum, $7^M.0$, on Jan. 16. As the series closed so soon after maximum, the date of that phase was determined by comparison with the curves for the previous five maxima, and is therefore entitled to less weight. The star was $7^M.3$ at the last observation.

Marengo, Ill., 1897 *May* 25.

7896. *V Pegasi.*

This star was looked for and not seen (limit $<12^M$), on 11 dates, from 1896 June 30 to Dec. 5, after which the following observations were secured:

1896	Dec. 23,	$12^M.5$
1897	Jan. 6,	11.4
	8,	10.5
	30,	9.0

Comparing with the Harvard observations, given in *Astrophysical Journal*, II, 357, the period seems to be $\frac{2460^d}{n}$. The value $n = 8$, or $P = 308^d$, satisfies all the observations, while there is no other value of n between 4 and 12, which is not contradicted by one or more observations. A period of about ten months therefore seems probable, bringing the next maximum in December, when it can be observed.

8324. *V Cassiopeae.*

A maximum, at $7^M.3$, 1897 Jan. 29, is indicated by 10 observations, beginning 1896 Nov. 22, when the star was $10^M.7$, and ending 1897 Feb. 13, at $7^M.7$. As the series closed so soon after the maximum, the date was determined by aid of the mean curve, and is therefore entitled to less weight.

OBSERVATIONS OF COMET 1896 VII,

MADE AT THE LICK OBSERVATORY OF THE UNIVERSITY OF CALIFORNIA,

By WILLIAM J. HUSSEY.

1897 Mt. Hamilton M.T.		∗	No. Comp.	☄ − ∗		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Jan. 20	7 3 54	8	8 , 8	+0 7.81	+4 17.8	4 36 14.87	−0 31 16.1	n9.249	0.730
22	8 22 4	9	8 . 8	+0 18.53	−7 4.3	4 42 45.62	−0 23 21.7	n8.301	0.732
Feb. 9	7 53 50	10	8 , 8	+0 2.19	−1 53.7	5 31 48.89	+1 16 23.8	8.514	0.712
25	9 0 32	12	8 , 8	−0 10.89	+3 37.4	6 8 19.98	+2 54 15.9	9.190	0.696
27	9 19 14	13	8 . 8	+0 3.88	+3 50.9	6 12 37.49	+3 5 38.3	9.295	0.695

Mean Places for 1897.0 of Comparison-Stars.

∗	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
8	4 36 5.24	+1.82	−0 35 37.8	+3.9	Copeland and Börgen. Göttingen 1282-3
9	4 42 25.29	+1.80	−0 16 20.9	+3.5	" " " " 1314–5
10	5 31 41.83	+1.87	+1 18 16.0	+1.5	11^M connected with ∗11
11	5 30 25.94	+1.87	+1 15 19.8	+1.5	Boss, Albany, A.G. Catal. 1813
12	6 8 29.00	+1.87	+2 50 38.8	−0.3	" " " " 2073
13	6 12 31.73	+1.88	+3 1 47.8	−0.4	" " " " 2111

The observations of Jan. 20 and 22 were made with the 12-inch and the others with the 36-inch telescope. Δα and Δδ were measured directly with the micrometer in all cases.

Lick Observatory, University of California, 1897 *May* 13.

FOURTH SATELLITE OF *JUPITER*.

Mr. PERCIVAL LOWELL telegraphs June 1: "DOUGLASS finds *Callisto* rotates in $16^d\ 16^h.7 \pm 2^h.7$."

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THE CONSTANT OF ABERRATION,

By C. L. DOOLITTLE.

In connection with my latitude work at South Bethlehem it was a part of the original plan to investigate the value of the constant of aberration, and possibly that of nutation. Since my removal from Bethlehem in 1895 this plan has remained in abeyance in consequence of more pressing demands upon my time. The building and equipping of an observatory and the inauguration of a new program of work have absorbed most of my energy.

In the spring and summer of 1895 the series of 1892–93* was discussed with the view to determining a value of the constant of aberration. This series possesses some advantages for this purpose, the stars being distributed as uniformly as practicable throughout the twenty-four hours of right-ascension, and each group — of which there were eleven — was observed both morning and evening at approximately the same interval before and after midnight. There were in all 107 pairs of stars distributed as follows in right-ascension.

$0^h - 1^h$	4 pairs	$12^h - 13^h$	5 pairs
1 – 2	4 “	13 – 14	3 “
2 – 3	4 “	14 – 15	5 “
3 – 4	4 “	15 – 16	5 “
4 – 5	5 “	16 – 17	4 “
5 – 6	5 “	17 – 18	4 “
6 – 7	5 “	18 – 19	5 “
7 – 8	5 “	19 – 20	5 “
8 – 9	5 “	20 – 21	5 “
9 – 10	4 “	21 – 22	4 “
10 – 11	4 “	22 – 23	5 “
11 – 12	4 “	23 – 24	4 “

The series extended from 1892 Oct. 10 to 1893 Dec. 27, 443 days.

There were 1744 determinations before midnight.
“ “ 1052 “ after “

We may therefore establish 2796 equations of the form

$$\varphi_0 + \Delta + Ax + By + Cz + Du + E\rho + T\eta = \varphi$$

where φ_0 is an assumed value of the latitude,
Δ a constant for the pair observed
A and B coefficients of the 14-month period,
C and D “ “ 12-month period,
$E\rho$ correction required on account of erroneous value of aberration,
$T\eta$ secular change in latitude.

Employing the common notation the reduction for aberration is $\mathrm{C}c' + \mathrm{D}d' = \kappa$ say,

That is, $20.4451\,[-c' \cos\omega \cos\odot - d' \sin\odot] = \kappa.$

Let ρ be the required correction to Struve's constant, $\Delta\kappa$ the corresponding correction to κ,

then $$\frac{20.4451}{20.4451+\rho} = \frac{\kappa}{\kappa+\Delta\kappa} \qquad \Delta\kappa = \frac{\kappa}{20.4451}\,\rho$$

The coefficient E is therefore $\frac{\kappa}{20.4451}$. As 20.4451 is an awkward divisor — a consideration of some importance when there are 2796 divisions required — this term is slightly modified as follows:

$$\Delta\kappa = \frac{\kappa}{20} \cdot \frac{20}{20.4451}\,\rho = \frac{\kappa}{20}\,\rho'$$

where $\rho' = \frac{20}{20.4451}\,\rho$ is employed as the unknown quantity. From a morning and an evening observation on any pair — which observations will of course be separated by an interval of several months — we have a pair of equations,

$$\varphi_0 + \Delta + A'x + B'y + C'z + D'u + E'\rho + T'\eta = \varphi'$$
$$\varphi_0 + \Delta + A''x + B''y + C''z + D''u + E''\rho + T''\eta = \varphi''$$

By subtraction

$$(A'-A'')x + (B'-B'')y + (C'-C'')z + (D'-D'')u$$
$$+ (E'-E'')\rho + (T'-T'')\eta = \varphi' - \varphi''$$

It was obvious from the outset that the 12 and 14-month terms could not be separated in a series of only 443 days; both were, however, retained for the sake of completeness, but the normal equations were also solved with the 12-month terms excluded. The results of both solutions will be found below.

For the purpose of more fully illustrating the formation and solution of the equations, the data for one pair of stars will be given in full, viz.:

	Mag.	α	δ
B.A.C. 16	4.9	$0^h\ 4^m\ 43^s$	$45^\circ\ 29'\ 15''$
Ll. 220	7.5	0 11 4	35 53 25

$z_1 - z_2$ approximately 10′.

---

* See *Astronomical Journal*, No. 322.

Date		x	y	z	u	ρ	η	Observed ς
1892 Dec. 2	1	+0.911	−0.411	−0.324	−0.946	+0.721	−0.076	″ 2.80
3	2	+ .918	− .397	− .307	− .952	+ .720	− .074	2.52
5	3	+ .928	− .371	− .274	− .962	+ .717	− .068	2.61
10	4	+ .953	− .302	− .189	− .982	+ .705	− .055	2.45
P. M. 12	5	+ .962	− .274	− .155	−0.988	+ .699	− .049	2.77
20	6	+ .987	− .160	− .012	−1.000	+ .665	− .028	2.64
23	7	+ .993	− .117	+ .042	−0.999	+ .650	− .019	2.75
26	8	+ .997	− .073	+ .096	− .995	+ .632	− .011	2.72
27	9	+0.998	−0.058	+0.113	−0.991	+0.625	−0.008	2.27
1893 July 19	10	−0.976	+0.218	−0.457	+0.889	−0.453	+0.551	3.31
23	11	−0.987	+ .162	− .515	+ .857	− .414	+ .562	3.03
Aug. 2	12	−1.000	+ .016	− .649	+ .760	− .310	+ .589	2.42
5	13	−1.000	− .028	− .687	+ .727	− .277	+ .597	2.59
A. M. 6	14	−0.999	− .044	− .700	+ .714	− .266	+ .600	2.79
7	15	− .998	− .058	− .711	+ .703	− .255	+ .603	2.44
8	16	− .997	− .071	− .723	+ .691	− .244	+ .605	3.22
9	17	− .996	− .087	− .735	+ .678	− .232	+ .608	2.80
10	18	−0.995	−0.101	−0.747	+0.665	−0.220	+0.611	3.38
1893 Oct. 31	19	−0.269	−0.963	−0.783	−0.622	+0.641	+0.835	3.10
Nov. 6	20	− .182	− .983	− .712	− .705	+ .672	+ .852	3.32
10	21	− .125	− .992	− .661	− .750	+ .689	+ .863	3.29
11	22	− .110	− .994	− .648	− .762	+ .693	+ .865	3.32
15	23	− .096	− .995	− .593	− .805	+ .705	+ .876	2.94
16	24	− .038	− .999	− .579	− .815	+ .708	+ .879	2.97
P. M. 26	25	+ .108	− .994	− .427	− .904	+ .723	+ .906	2.81
30	26	+ .167	− .986	− .362	− .932	+ .722	+ .918	3.33
Dec. 4	27	+ .223	− .975	− .296	− .953	+ .719	+ .928	2.65
6	28	+ .252	− .968	− .260	− .965	+ .715	+ .934	3.21
7	29	+ .266	− .964	− .241	-- .970	+ .713	+ .937	2.53
10	30	+ .307	− .952	− .192	− .981	+ .706	+ .945	2.35
13	31	+ .349	− .937	− .139	−0.990	+ .696	+ .953	2.82
20	32	+ .443	− .896	− .016	−1.000	+ .667	+ .972	3.21
24	33	+ .494	− .870	+ .054	−0.998	+ .645	+ .983	2.87
25	34	+ .507	− .862	+ .071	− .997	+ .639	+ .986	2.24
26	35	+0.520	−0.854	+0.091	−0.996	+0.633	+0.989	3.37

These are now combined by subtraction as follows:

								$\sqrt{p}$
10−1	−1.887	+0.629	−0.133	+1.835	−1.174	+0.627	+0.51	0.64
11−2	− .905	+ .559	− .208	+ .809	− .134	+ .636	+ .51	.64
12−3	− .928	+ .387	− .375	+ .722	−1.027	+ .657	− .19	.64
13−4	− .953	+ .274	− .498	+ .709	−0.982	+ .652	+ .14	.64
14−5	− .961	+ .230	− .515	+ .702	− .965	+ .619	+ .02	.64
15−6	− .985	+ .102	− .699	+ .703	− .920	+ .631	− .20	.64
16−7	− .990	+ .046	− .765	+ .690	− .894	+ .624	+ .47	.64
17−8	− .993	− .014	− .831	+ .673	− .864	+ .619	+0.08	.64
18−9	−1.993	−0.043	−0.860	+1.659	−0.845	+0.619	+1.11	0.64
19 . 20−10	+0.751	−1.191	−0.290	−1.553	+1.109	+0.293	−0.10	0.72
21 , 22−11	+ .870	− .155	− .140	− .613	+ .105	+ .302	+ .27	.72
23 , 24−12	+0.933	−1.013	+ .063	− .570	+1.016	+ .289	+ .54	.72
25 , 26−13	+1.137	−0.962	+ .292	− .645	+0.999	+ .315	+ .48	.72
27 , 28−14	+ .236	− .927	+ .422	− .674	+ .983	+ .331	+ .14	.72
29 , 30−15	+ .284	− .900	+ .493	− .679	+ .966	+ .337	.00	.72
31 , 32−16	+ .393	− .845	+ .645	− .686	+ .925	+ .357	− .21	.72
33 , 34−17	+ .496	− .779	+ .797	− .675	+ .874	+ .376	− .25	.72
35−18	+1.515	−0.753	+0.838	−1.661	+0.853	+0.378	−0.01	0.64

In the assignment of weights those pairs whose difference of zenith-distance was fifteen revolutions of the micrometer-screw (12′.6) or more were given half weight only.

As appears from the above, one morning observation may be combined with the mean of two or more evening observations, or *vice versa*. Also the same morning or evening observation may enter into more than one of the combination-equations — thus the morning series above is combined with each of the two evening series.

When one morning equation is combined with one evening equation, each of weight unity, the weight of the result is

$$\frac{p_1 \cdot p_2}{p_1 + p_2} = 0.5$$

If the same observation-equation enters into two combinations it is given in each a weight of 0.7, the weight of the combination being 0.412.

When two equations are combined into a single mean this has the weight 2.

When three or more are combined the weight 3 is given.

In this manner were formed 1219 equations which may be called difference-equations.

Where the original equations were the result of observations made within an interval of a few days the coefficients were so nearly equal that frequently several of the difference-equations could be combined into one without loss of accuracy.

For example take the following group of five equations.

$$\begin{array}{rrrrrrcrl}
-1.09\,x & +1.65\,y & +1.15\,z & +1.35\,u & -1.42\,\rho & +0.65\,\eta & = & +0\overset{\prime\prime}{.}27 & \sqrt{p} = 0.64 \\
-1.17 & +1.60 & +1.10 & +1.43 & -1.40 & +0.64 & = & -0.19 & \phantom{\sqrt{p} =}\ 0.64 \\
-1.20 & +1.58 & +1.06 & +1.46 & -1.39 & +0.63 & = & +0.32 & \phantom{\sqrt{p} =}\ 0.64 \\
-1.05 & +1.66 & +1.16 & +1.30 & -1.26 & +0.66 & = & +0.15 & \phantom{\sqrt{p} =}\ 0.76 \\
-1.11 & +1.63 & +1.12 & +1.35 & -1.25 & +0.65 & = & +0.34 & \phantom{\sqrt{p} =}\ 0.64 \\
\hline
-5.62\,x & +8.12\,y & +5.59\,z & +6.89\,u & -6.72\,\rho & +3.23\,\eta & = & +0.89 & \sqrt{P} = 0.305 \\
-1.71\,x & +2.48\,y & +1.70\,z & +2.10\,u & -2.05\,\rho & +0.99\,\eta & = & +0.27 &
\end{array}$$

The constituent equations are added as shown above, the final one is the summation-equation multiplied by the square root of its weight.

For determining this final weight let $p_1, p_2 \cdots p_n$ be the weights of the individual equations.

Weight of sum is

$$\frac{p_1 \cdot p_2 \cdots p_n}{(p_1 \cdot p_2 \cdots p_{n-1}) + (p_1 \cdot p_3 \cdots p_n) + \cdots + (p_2 \cdots p_{n-1} \cdot p_n)}$$

By means of a simple tabulation of the terms of this formula, for the values of p which practically occurred, the weights were very readily found.

As a result of this process of grouping, the number of equations was reduced to 190. These were solved in the usual manner with the following result.

$$\begin{aligned}
x &= r \cos R = -0\overset{\prime\prime}{.}145 \pm 0\overset{\prime\prime}{.}103 \\
y &= r \sin R = -0.063 \pm 0.059 \\
z &= \gamma \cos \Gamma = -0.016 \pm 0.073 \\
u &= \gamma \sin \Gamma = -0.105 \pm 0.065 \\
\rho &= \qquad\quad -0.1049 \pm 0.0093 \\
\eta &= \qquad\quad -0.047 \pm 0.093
\end{aligned}$$

The probable error of a single equation of weight unity $= \pm 0''.184$.

The resulting periodic terms of the latitude are therefore

$$\Delta\varphi = 0''.158 \cos(204^\circ - N) + 0''.106 \cos(261^\circ - \odot)$$

where $N = 0^\circ.837\,(t - 2412465)$

On account of the impossibility of separating the 12 and 14-month terms in so limited a series, this expression is quite indeterminate, as shown by the large probable errors of x, y, z and u. The indetermination does not, however, extend to ρ. Referring to the early part of this article for the significance of ρ, we find the correction to STRUVE's value of the aberration-constant to be

$$\frac{20.4451}{20}\,\rho = 0''.1072 \pm 0''.0095$$

And the resulting value for this constant

20″.552 ±0″.0095

A second solution of the normal equations, excluding the annual terms, gave the following values:

$$\begin{aligned}
x &= r \cos R = -0\overset{\prime\prime}{.}050 \pm 0\overset{\prime\prime}{.}010 \\
y &= r \sin R = -0.127 \pm 0.008 \\
\rho &= \qquad\quad -0.1075 \pm 0.0091 \\
\eta &= \qquad\quad +0.004 \pm 0.023
\end{aligned}$$

From x and y, $\Delta\varphi = 0''.137 \cos(248^\circ - N)$

Correction of STRUVE's constant, $+0''.1099 \pm 0''.0093$.

Resulting value **20″.555 ±0″.009.**

Finally, if we exclude from the equations everything except ρ, we find

Correction = +0″.0885
Constant **20″.534**

Assuming that the latitude-variation may be represented by a single periodic term, and that the observations are uniformly distributed throughout one full period, as regards both right-ascension of stars and date of observation, we should expect the last two values to be practically equal. Although neither of the supposed conditions is fully met, both are approximately so.

As the final result of this investigation we find for the constant of aberration the value,

20″.55 ±0.01

Flower Observatory, University of Pennsylvania, 1897 *May* 27.

SYNTHETICAL STATEMENT OF THE THEORY OF THE POLAR MOTION,

BY S. C. CHANDLER.

1. In the course of my various articles on the motion of the pole a considerable number of formulas have been introduced, as I had occasion to use them, without giving their derivation, which in so simple a theory I assumed would be obvious, especially as the notation was consistent throughout. But it does not seem superfluous to give their development in this place in an orderly form.

The problem may be stated as follows. Given an observed motion of the pole of rotation, relative to the pole of figure, which may be resolved into two components, one an ellipse having a mean period of a year, the other a circle having a mean period of 428.6 days, the direction of both motions being from west to east; it is required to find the mathematical relations involved. Let us examine these components separately.

2. *Annual component.* The coordinates of this motion having been shown by observation to be simple harmonic functions of the time, the arguments of which may be conveniently expressed in terms of the longitude of the mean or fictitious sun, $\odot$, —let the coordinates of the pole of figure, reckoned from the pole of rotation as origin, be x'_2, y'_2, respectively parallel to the minor and major axes, b, a, of the observed ellipse. Let L be the longitude of the mean sun on the date when the pole is at the vertex of the major axis. Then we have

$$(1)\quad \left\{\begin{aligned} x'_2 &= \tfrac{1}{2} b \sin(\odot - L) = \rho \sin\beta \\ y'_2 &= \tfrac{1}{2} a \cos(\odot - L) = \rho \cos\beta \end{aligned}\right.$$

where β is the angle at the center of the ellipse between the pole and the vertex of the major axis, and ρ is the radius-vector.

Let x_2, y_2, be the coordinates in a system referred to the Greenwich meridian as the axis of y, and ω be the angle which the major axis forms with the Greenwich meridian, reckoned towards the east. Then for transformation we have

$$(2)\quad x'_2 = x_2 \cos\omega - y_2 \sin\omega \qquad y'_2 = x_2 \sin\omega + y_2 \cos\omega$$

$$(3)\quad x_2 = x'_2 \cos\omega + y'_2 \sin\omega \qquad y_2 = -x'_2 \sin\omega + y'_2 \cos\omega$$

From (1) and (3)

$$(4)\quad \left\{\begin{aligned} x_2 &= \tfrac{1}{2}(b \cos\omega \cos L + a \sin\omega \sin L) \sin\odot \\ &\qquad + \tfrac{1}{2}(a \sin\omega \cos L - b \cos\omega \sin L) \cos\odot \\ y_2 &= \tfrac{1}{2}(a \cos\omega \sin L - b \sin\omega \cos L) \sin\odot \\ &\qquad + \tfrac{1}{2}(b \sin\omega \sin L + a \cos\omega \cos L) \cos\odot \end{aligned}\right.$$

Putting

$$(5)\quad \left\{\begin{aligned} m \sin M &= \tfrac{1}{2}(b \cos\omega \sin L - a \sin\omega \cos L) \\ m \cos M &= \tfrac{1}{2}(b \cos\omega \cos L + a \sin\omega \sin L) \end{aligned}\right.$$

$$(6)\quad \left\{\begin{aligned} n \sin N &= -\tfrac{1}{2}(b \sin\omega \sin L + a \cos\omega \cos L) \\ n \cos N &= -\tfrac{1}{2}(b \sin\omega \cos L - a \cos\omega \sin L) \end{aligned}\right.$$

we get

$$(7)\quad x_2 = m \sin(\odot - M) \quad , \quad y_2 = n \sin(\odot - N)$$

Multiplying the 1st and 2d of (5) and (6) by $\cos L$ and $\sin L$, respectively, the differences give

$$m \sin(L - M) = \tfrac{1}{2} a \sin\omega \quad , \quad n \sin(L - N) = \tfrac{1}{2} a \cos\omega \qquad (8)$$

Hence the angle at which the transverse axis lies east of Greenwich may be found by

$$\tan\omega = \frac{m \sin(L - M)}{n \sin(L - N)} \qquad (9)$$

and the length of this axis is

$$a = 2\frac{m \sin(L - M)}{\sin\omega} = 2\frac{n \sin(L - N)}{\cos\omega} \qquad (10)$$

Reversing the multipliers we get by addition

$$m \cos(L - M) = \tfrac{1}{2} b \cos\omega \quad , \quad n \cos(L - N) = -\tfrac{1}{2} b \sin\omega \qquad (11)$$

whence the length of the conjugate axis is

$$b = 2\frac{m \cos(L - M)}{\cos\omega} = -2\frac{n \cos(L - N)}{\sin\omega} \qquad (12)$$

Or we can get the axes by squaring (8) and (11) and adding,

$$\left.\begin{aligned} a &= 2\sqrt{m^2 \sin^2(L - M) + n^2 \sin^2(L - N)} \\ b &= 2\sqrt{m^2 \cos^2(L - M) + n^2 \cos^2(L - N)} \end{aligned}\right\} \quad (13)$$

To find L we have from (1) and (7) (14)

$$\rho^2 = x'^2_2 + y'^2_2 = x^2_2 + y^2_2 = m^2 \sin^2(\odot - M) + n^2 \sin^2(\odot - N)$$

the differentiation of which gives the condition of maximum for ρ

$$m^2 \sin 2(L - M) + n^2 \sin 2(L - N) = 0 \qquad (15)$$

which can be solved by trial to get the unknown, L. Or solving (15) directly we find

$$\tan 2L = \frac{m^2 \sin 2M + n^2 \sin 2N}{m^2 \cos 2M + n^2 \cos 2N} \qquad (16)$$

which completes the determination of the elements of the ellipse in terms of the auxiliaries furnished by observation, through the observed coordinates, x_2, y_2, by means of (7).

A useful check-equation

$$a^2 + b^2 = 4(m^2 + n^2) \qquad (17)$$

is furnished, by the distance between the vertices of the principal axes, through the square of (13).

For the elucidation of the properties of this component of the motion of the pole, we get from (1)

$$\rho^2 = x'^2_2 + y'^2_2 = \left(\frac{b}{2}\right)^2 \sin^2(\odot - L) + \left(\frac{a}{2}\right)^2 \cos^2(\odot - L) \qquad (18)$$

whence the equation of the ellipse

$$\rho = \frac{a}{2}\sqrt{1 - e^2 \sin^2(\odot - L)} \qquad (19)$$

The relation of the angle at the center to the argument of the function is

$$\tan\beta = \frac{b}{a} \tan(\odot - L) \qquad (20)$$

The linear velocity of the pole

$$V = \frac{a}{2}\sqrt{1-e^2\cos^2(\odot-L)}\;.\;d\odot \tag{21}$$

resolved into the velocities in the direction of the radius-vector and perpendicular to it, gives

$$V = \sqrt{d^2\rho+\rho^2 d^2\beta}$$

The radial and angular velocities are

$$d\rho = -\frac{a^2e^2}{8\rho}\sin 2(\odot-L)\,d\odot \tag{22}$$

$$d\beta = \frac{b}{a}\sec^2(\odot-L)\cos^2\beta\,d\odot = \frac{ab}{4\rho^2}\,d\dot{\odot} \tag{23}$$

Consequently the double area described by the radius-vector in the unit of time is

$$\rho^2 d\beta = \frac{ab}{4}\,d\odot \tag{24}$$

thus a constant, agreeably with the proportionality of times to areas characteristic of harmonic motion.

3. *Fourteen months' component.* The coordinates of the circular motion with radius r_1, referred to the meridian of Greenwich as the axis of y, are

$$x_1 = r_1\sin(t-T_1)\,\theta \quad , \quad y_1 = r_1\cos(t-T_1)\,\theta \tag{25}$$

where t is the date of observation, T_1 any epoch when the pole of figure passes the meridian between the pole of rotation and Greenwich by virtue of this component of the motion, and θ is the daily angular motion.

4. *Variation of latitude.* The coordinates of the pole in virtue of both of the components will be

$$x = x_1 + x_2 \quad , \quad y = y_1 + y_2 \tag{26}$$

whence by (7) and (25)

$$\left.\begin{aligned} x &= r_1\sin(t-T_1)\,\theta + m\sin(\odot-M) \\ y &= r_1\cos(t-T_1)\,\theta + n\sin(\odot-N) \end{aligned}\right\} \tag{27}$$

For a station in longitude λ, reckoned west from Greenwich, we have

$$\varphi-\varphi_0 = x\sin\lambda - y\cos\lambda \tag{28}$$

where φ is the instantaneous, and φ_0 the mean latitude. Or, if

(29) $x = r\sin\alpha \quad , \quad y = r\cos\alpha$
where the angle α is reckoned east from Greenwich,
we have $\varphi-\varphi_0 = -r\cos(\alpha+\lambda)$

Substituting (27) in (28),

$$\left.\begin{aligned} \varphi-\varphi_0 = &-r_1\cos[\lambda+(t-T_1)\,\theta] \\ &+m\sin(\odot-M)\sin\lambda \\ &-n\sin(\odot-N)\cos\lambda \end{aligned}\right\} \tag{30}$$

This can be reduced to two terms by transforming the auxiliaries. Put

$$\left.\begin{aligned} \mu &= m\sin M & \nu &= n\sin N \\ \mu' &= m\cos M & \nu' &= n\cos N \end{aligned}\right\} \tag{31}$$

and also

$$\left.\begin{aligned} r_2\sin G' &= -\mu'\sin\lambda + \nu'\cos\lambda \\ r_2\cos G' &= +\mu\sin\lambda - \nu\cos\lambda \end{aligned}\right\} \tag{32}$$

Then (30) becomes

$$\varphi-\varphi_0 = -r_1\cos[\lambda+(t-T_1)\,\theta] - r_2\cos(\odot-G') \tag{33}$$

5. *Variation of azimuth and longitude.* The variation caused in the azimuth, A, of an object, from its mean value A_0, will manifestly be

$$A - A_0 = (x\cos\lambda+y\sin\lambda)\sec\varphi \tag{34}$$

Similarly the variation in longitude is

$$\lambda-\lambda_0 = -(x\cos\lambda+y\sin\lambda)\tan\varphi \tag{35}$$

In both of these expressions we can substitute the values of the rectangular coordinates by (27), and get analogous expressions to those in latitude, expressed directly in the coefficients, if desired.

6. *Numerical values of the coefficients.* It may be useful to add here the adopted values of the coefficients for the above formulas determined from a discussion of the observations. For the fourteen months' term

$$\left.\begin{aligned} &T_1 = 1865 \text{ Mar. } 31\ (2402327) + 428^{d}.6\,\mathrm{E} + 55^{d}\sin\Psi \\ &r_1 = 0''.135 + 0''.05\sin\Psi \\ &P = 428^{d}.6 + 5^{d}.26\cos\Psi, \qquad \theta = \frac{360^\circ}{P} \\ &\Psi = (t-2402327)\;0^\circ.015 \end{aligned}\right\} \tag{36}$$

For the annual term

$$m = 0''.11 \qquad n = 0''.11 \qquad M = 300^\circ \qquad N = 270^\circ \tag{37}$$

whence by (31) and (32)

$$\left.\begin{aligned} r_2\sin G' &= -0''.0550\sin\lambda \\ r_2\cos G' &= -0''.0953\sin\lambda + 0''.1100\cos\lambda \end{aligned}\right\} \tag{38}$$

The law of the coefficients of the fourteen months' term, in (36), was developed empirically from the observations between 1825–90, in *A.J.* 322, and is confirmed by the observations of 1890–96 inclusive, as will be shown in an article yet to be published. A tabulation will be found in *A.J.* 322 and 360.

The coefficients of the annual term, in (37), were found from a discussion of the observations of 1890–93, in *A.J.* 323 and 329, and the later observations, 1894–96.5, confirm them, as shown in *A.J.* 402, giving no material improvement.

7. *Numerical equations.* Substituting the coefficients (37) in (16), (9), (10) and (12) or (13), we have the elements of the ellipse

$$\left.\begin{aligned} L &= 15^\circ & a &= 0''.30 \\ \omega &= 45^\circ & b &= 0''.08 \end{aligned}\right\} \tag{39}$$

as given in *A.J.* 329. Also, $e = 0.9638$.

From (27) and (37)

$$\left.\begin{aligned} x &= r_1\sin(t-T_1)\,\theta + 0''.11\sin(\odot-300^\circ) \\ y &= r_1\cos(t-T_1)\,\theta + 0''.11\cos\odot \end{aligned}\right\} \tag{40}$$

as in *A.J.* 360 and 392, where these coordinates are tabulated for 1893–97 inclusive. Then the variation of latitude may be found by (28). Or (29) may be used, after tabulating r and α, as in *A.J.* 392. Or directly, by (30) and (37),

$$(41)\quad \left\{ \begin{aligned} q-q_0 = &-r_1\cos[\lambda+(t-T_1)\theta] \\ &+0''.11\sin(\odot-300^\circ)\sin\lambda \\ &-0''.11\cos\odot\cos\lambda \end{aligned} \right.$$

or, if preferred, the values of r_2 and G' found by (38) may be inserted in (33).

8. It is hoped that the preceding synopsis of the theory will be of some assistance in interpreting the various articles on the subject in this *Journal*, the notation and formulas of which strictly correspond to those here used, so that there can be no confusion.

There is only one point on which there will be any uncertainty in the application of the formulas, and this is so important that it must be spoken of here. In *A.J.* 402 it has been shown that there is no indication, from the observations of 1890–96, of any progressive alteration in the dimensions or position of the annual ellipse. On the other hand the investigation in *A.J.* 322 makes it apparent that such changes are going on, in long period, analogous to those in the fourteen months' term. But, for want of sufficiently extensive or accurate observations in the United States long anterior to 1890, it is impossible to determine the nature of the changes in the elliptical component to which the variations shown by the European observations, thus only in one coordinate, correspond. Therefore, in computing variations of latitude before 1890, the question arises whether the values to be employed for the annual term should be those of eq. (52) in *A.J.* 322, or those of the elliptical elements developed from observations since 1890. The differences are not large or practically important. My own opinion is, from such evidence as is available, that after about 1880 it will be better to use the latter, but previously to that date to have recourse directly to the former. The difficulty is one which can only be settled by time and the development, from future observation, of the nature of the slow changes in the ellipse which are probably in operation.

9. Some doubt has been expressed, in a quarter entitled to respectful consideration, on the point whether the annual term in the motion of the pole can be as eccentric as my determination of it ($e=0.96$) requires. In the entire absence of any theoretical knowledge of the cause of this motion, other than the vaguest surmise not yet brought within the range of analysis, any rational opinion which can be formed in the present state of the subject must rest on the testimony of observation alone. It seems to me well, therefore, that all the evidence which we have should be brought to bear in the most direct manner upon this question, so that any objection, whether on the ground of the competency of the observations or the correctness of the method of employing them, may be fairly considered. Although the topic is logically outside the intended scope of this article, it is convenient to set it forth here.

On pp. 83 and 130, *A.J.* Vol. XIV, I have given the coordinates x_2, y_2, deduced directly from the observations for the period 1890.0–94.0; and recently in *A.J.* 402, similar values for the period 1894.0–96.5. From these the observed radius of the annual motion, $\rho = \sqrt{x_2^2+y_2^2}$, may be directly found. These values are given — arranged in order of the longitude of the mean sun — in the columns "Obs'd ρ," in the first two sections of the accompanying table, which contain, respectively, the observations March–August, and September–February. The third section of the table gives the corresponding means, which, combining opposite seasons of the year, are presumably free from errors which might affect data obtained at the same season.

March–August					September–February					Mean			
⊙	Obs'd ρ	r	Comp'd ρ	O—C	⊙	Obs'd ρ	v	Comp'd ρ	O—C	Obs'd ρ	v	Comp'd ρ	O—C
°	″	″	″	″	°	″	″	″	″	″	″	″	″
1.0	0.180	+0.073	0.145	+0.035	183.0	0.139	+0.032	0.147	−0.008	0.160	+0.053	0.146	+0.014
5.2	.139	+ .032	.148	− .009	187.2	.094	− .013	.149	− .055	.117	+ .010	.118	− .031
20.2	.188	+ .081	.150	+ .038	198.1	.114	+ .007	.150	− .036	.151	+ .044	.150	+ .001
24.3	.193	+ .086	.148	+ .045	202.3	.144	+ .037	.149	− .005	.168	+ .061	.148	+ .020
39.4	.139	+ .032	.137	+ .002	217.3	.108	+ .001	.139	− .031	.124	+ .017	.138	− .014
50.2	.156	+ .049	.125	+ .031	232.3	.113	+ .006	.121	− .008	.134	+ .027	.123	+ .011
54.4	.100	− .007	.118	− .018	236.5	.131	+ .024	.116	+ .015	.116	+ .009	.117	− .001
69.5	.130	+ .023	.092	+ .038	247.3	.161	+ .054	.096	+ .065	.145	+ .038	.094	+ .051
73.6	.077	− .030	.085	− .008	251.5	.079	− .028	.087	− .008	.078	− .029	.086	− .008
84.4	.051	− .056	.065	− .014	262.5	.082	− .025	.069	+ .013	.067	− .040	.067	.000
88.6	.120	+ .013	.058	+ .062	266.7	.080	− .027	.060	+ .020	.100	− .007	.059	+ .041
99.5	.095	− .012	.042	+ .053	281.5	.000	− .107	.042	− .042	.048	− .059	.042	+ .006
103.7	.036	− .071	.041	− .005	285.5	.000	− .107	.040	− .040	.018	− .089	.040	− .022
118.7	.064	− .043	.053	+ .011	300.8	.057	− .050	.056	+ .001	.060	− .047	.055	+ .005
122.9	.023	− .084	.060	− .037	311.7	.120	+ .013	.076	+ .044	.072	− .035	.068	+ .004
133.7	.085	− .022	.080	+ .005	315.9	.100	− .007	.084	+ .016	.092	− .015	.082	+ .010
137.9	.137	+ .030	.087	+ .050	330.9	.121	+ .014	.111	+ .010	.129	+ .022	.099	+ .030
148.8	.063	− .044	.108	− .045	335.0	.203	+ .096	.118	+ .085	.133	+ .026	.113	+ .020
153.0	0.121	+0.014	0.115	+0.006	350.1	0.114	+0.007	0.137	−0.023	0.118	+0.011	0.126	−0.008

Now, in the first place, if the annual motion were a circular one these observed values of ρ should conform to their average value, which is $0''.107$, without tendency to system in the deviations from it which will be found in the columns "r." The testimony of these columns is most distinctly against this hypothesis of circular motion. Aside from accidental deviations the values range quite regularly between maxima and minima three months apart.

In the second place, let us make a comparison with the theory of elliptical motion. From eq. (19) of section 2 and the numerical values in (39) we have

$$\rho = \frac{a}{2}\sqrt{1-e^2\sin^2(\odot-L)} = 0''.15\sqrt{1-0.929\sin^2(\odot-15^\circ)}$$

whose values will be found in the columns "Comp'd ρ." The deviations from the observed values are in the columns O−C. The conformity exhibited is extremely satisfactory. Nor can any materially smaller value of the eccentricity be used without violating the observed distances.

An independent argument may be drawn from an analogous treatment of the other polar coordinate, the angle from the center, β. If we put in eq. (2) the value of $\omega = 45^\circ$, we have from (1)

$$\tan\beta = \frac{x_2-y_2}{x_2+y_2} \tag{42}$$

Then from the observed values of x_2, y_2, in the places above cited, we get from (42) a series of observed values of β. Taking the means, as in the case of the radius-vector, for the data at opposite seasons of the year, to eliminate possible effects of temperature, we have the column "Obs'd β" in the following table, corresponding to that for ρ in the last section of the foregoing table. The column v gives similarly the deviations from the hypothesis of circular motion; equivalent to putting $a = b$ in eq. (20), so that $\beta = \odot - L$. For the corresponding comparison with the elliptic theory we have from (20) and (39),

$$\tan\beta = 0.267\tan(\odot-15^\circ)$$

as given in the column "Comp'd β"; followed by O−C as before. It should be noted that the assumption as to ω in deducing (42) does not vitiate the proof.

Obs'd β	v	Comp'd β	O−C
°	°	°	°
− 12	+ 1	− 3	− 9
− 18	− 9	− 3	−15
+ 13	+ 9	+ 1	+12
− 7	−15	+ 2	− 9
+ 13	−10	+ 7	+ 6
+ 5	−31	+ 12	− 7
− 7	−47	+ 13	−20
+ 46	− 7	+ 21	+25
+ 12	−45	+ 22	−10
+ 46	−22	+ 34	+12
+ 80	+ 7	+ 41	+39
+ 81	− 4	+ 73	+ 8
+118	+28	+ 88	+30
+149	+44	+135	+14
+146	+34	+146	0
+145	+25	+154	− 9
+174	+45	+162	+12
+135	− 2	+165	−30
+185	+38	+170	+15

The foregoing demonstration, both from the radius and angle vectors, appears to me unobjectionable and concluclusive; and would authorize us to reject, as incorrect or imperfect, any speculation or dynamical theory which is incompatible with an annual motion closely approaching a harmonic rectilinear vibration of the pole of rotation across mean position on the earth's surface.

OBSERVATIONS OF COMET 1896 VI (= 1889 V),

MADE AT THE U.S. NAVAL OBSERVATORY,

BY PROF. STIMSON J. BROWN,

[Communicated by Prof. WM. HARKNESS, U.S.N., Astronomical Director.]

1896–7 Washington M.T.		*	No. Comp.	☄ − *		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m			m s	′ ″	h m s	° ′ ″		
Nov. 6	7 21.1	1	18 , 5	−0 39.28	−3 6.2	22 28 31.31	−11 57 46.2	7.2148	0.8347
25	8 54.6	3	6 , 4	−0 16.94	+3 54.3	22 52 28.69	− 8 9 13.6	9.4361	0.7966
Dec. 9	9 19.7	5	4 , 4	+0 9.56	+0 53.4	23 13 44.06	− 5 5 16.0	9.5644	0.7702
23	6 32.8	6	7 , 0	+1 39.26	. . .	23 36 53.40	. . .	9.1274	. .
	7 3.5	7	0 . 3	. . .	−0 9.4	. . .	− 1 53 40.1	. .	0.7589
	7 16.0	7	1	. . .	. . .	23 36 56.78	. . .	9.2427	. .
	7 21.0	7	1	. . .	. . .	. . .	− 1 53 30.7	. .	0.7575
24	6 42.0	9	5 , 4	+0 4.29	−1 57.6	23 38 37.66	− 1 39 51.5	9.2427	0.7569
	7 12.8	8	6	+2 0.80	. . .	23 38 39.89	. . .	9.3183	. .
30	7 0.7	10	5 , 5	+0 16.58	−5 36.94	23 49 11.91	− 0 15 14.5	9.3535	0.7445
1897 Jan. 6	6 43.2	11	6 , 8	+0 9.81	+6 32.2	0 1 45.57	+ 1 23 45.7	9.3435	0.7304
23	7 26.4	12	8 , 6	+0 12.01	−2 51.1	0 33 27.09	+ 5 24 58.6	9.5481	0.7024
Feb. 4	7 13.8	14	0 , 5	. . .	−2 54.8	. . .	+ 8 15 22.6	. .	0.6844
	7 30.0	14	5 , 0	−0 10.02	. . .	0 56 30.98	. . .	9.5739	. .

Mean Places for 1896.0 and 1897.0 of Comparison-Stars.

*	α (h m s)	Red. to app. place (s)	δ (° ′ ″)	Red. to app. place (″)	Authority
1	22 29 6.80	+3.85	−11 54 58.3	+18.3	Washington Transit Circle
2	22 53 4.82	+3.69	− 8 17 25.7	+19.9	½ (Schj. 9121 + W.B. 1055)
3	22 52 41.94	+3.69	− 8 13 27.8	+19.9	12ᴹ from *2. Δα −22ˢ.88; Δδ +3′ 57″.9
4	23 12 31.88	+3.60	− 5 5 27.7	+21.3	W. Bessel 198
5	23 13 31.38	+3.60	− 5 6 30.7	+21.3	11ᴹ from *4. Δα +59ˢ.50; Δδ −63″.0
6	23 35 10.60	+3.54	− 1 56 15.1	+22.4	W. Bessel 678
7	23 36 53.24	+3.54	− 1 53 53.1	+22.4	11ᴹ from *6. Δα +1ᵐ 42ˢ.64; Δδ +2′ 22″.0
8	23 38 30.64	+3.53	− 1 38 16.4	+22.5	11ᴹ from *9. Δα +1ᵐ 55ˢ.08; Δδ +2′ 8″.7
9	23 36 35.56	+3.53	− 1 10 2.6	+22.5	W. Bessel 708
10	23 48 50.99	+3.51	− 0 10 0.2	+22.8	⅓ (R. 11727 + Mun. II, 32861 + Cop. B. 6527)
11	0 1 35.30	+0.46	+ 1 17 14.71	− 1.40	Boss, Albany A.G., 3
12	0 33 14.66	+0.42	+ 5 27 33.8	+ 4.54	W. Bessel 521
13	0 57 7.94	+0.43	+ 8 16 5.8	+ 5.30	Yarnall 840
14	0 56 40.57	+0.43	+ 8 14 12.1	. .	From *13; Δα −27ˢ.34; Δδ −1′ 53″.7

Dec. 9. Faint nebulous object at first observed for Comet Brooks in α $23^h\,13^m\,4^s.54$, δ −4° 58′ 43″.6.

Dec. 23. Faint nebulous object, 24^s preceding and 1′.8 S. No motion in either object observed on the 9th and 23d. Both objects were carefully observed on account of the suspected division of the 1889 Comet. The last two observations were made by estimating the time of coincidence with the 12ᴹ star.

All the observations were made with the 26-inch equatorial, using a magnifying power of 200. The following corrections for reduction to a common epoch have been applied: Dec. 9, Δα $-0^s.48$ for $-7^m.25$. Dec. 24, Δα $-0^s.77$ for $-10^m.5$. Dec. 25, Δα $+0^s.83$ for $11^m.2$. Jan. 6, Δδ +0″.2 for $+0^m.3$. Jan. 23, Δδ +11″.4 for $+19^m.5$.

OBSERVATIONS OF *SAPPHO*,

FROM PHOTOGRAPHIC MEASUREMENTS,

COMMUNICATED BY F. P. LEAVENWORTH.

1893 Northfield M.T. (h m s)	*	☄ — * Δα (m s)	☄ — * Δδ (′ ″)	☄'s mean α (h m s)	☄'s mean δ (° ′ ″)	log pΔ for α	log pΔ for δ
Dec. 28 11 27 24	1	+2 19.16	+ 4 49.8	7 42 2.09	+7 45 13.3	*n*9.265	0.726
28 11 27 24	2	+1 30.11	− 9 36.7	7 42 2.11	+7 45 15.5	*n*9.265	0.726
28 11 27 24	3	+0 33.84	+22 43.8	7 42 2.10	+7 45 12.0	*n*9.265	0.726
28 11 27 24	4	+0 13.58	+26 16.1	7 42 2.26	+7 45 13.2	*n*9.265	0.726
28 11 27 24	5	−0 2.16	+ 8 54.6	7 42 2.09	+7 45 12.4	*n*9.265	0.726
28 11 27 24	6	−0 36.58	+42 11.2	7 42 2.07	+7 45 14.7	*n*9.265	0.726

Mean Places for 1893.0 of Comparison-Stars.

*	α (h m s)	δ (° ′ ″)	Authority
1	7 39 42.93	+7 40 23.5	Weisse's Bessel 1142
2	7 40 32.00	+7 54 52.2	Weisse's Bessel 1163
3	7 41 28.26	+7 22 28.2	P. 9528
4	7 41 48.68	+7 18 57.1	Göttingen 1833
5	7 42 4.25	+7 36 17.8	½ (Weisse's Bessel + Lalande 15161)
6	7 42 38.63	+7 3 3.5	½ (Weisse's Bessel + Lalande 15188)

The photograph from which these measures were obtained was taken by Dr. H. C. WILSON with the 8½-inch telescope of the Goodsell Observatory. The measurements and reductions were made by E. A. LEE and FRANK M. HEWETT, students of the University of Minnesota. The places were deduced for the beginning of the year, and are therefore corrected for precession, nutation and annual aberration. Refraction also has been applied. The discrepancies in the individual places may be accounted for in part by the poor places of the stars.

University of Minnesota.

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MEASURES OF DOUBLE STARS,

MADE AT THE OBSERVATORY OF THE UNIVERSITY OF MINNESOTA,

By F. P. LEAVENWORTH.

These measures were made with the 10½-inch equatorial mostly during the summer of 1896. A list of stars that especially needed measurement was furnished by Prof. Burnham, who also kindly added the notes relating to their motion. The right-ascensions and declinations are for the equinox of 1900.0.

β 500 8^{M} 8^{M}

$\alpha = 0^{h}\,49^{m}\,56^{s}$, $\delta = +30^{\circ}\,8'$

	°	″
1896.631	293.7	0.64
.822	286.0	0.61
1896.726	289.8	0.62

Very little change in angle.

Σ1306 5^{M} 9^{M}

$\alpha = 9^{h}\,1^{m}\,37^{s}$, $\delta = +67^{\circ}\,32'$

1897.230	206.7	1.22
.343	210.7	1.26
1897.286	208.7	1.24

The apparent motion is nearly rectilinear, but it is probably a binary system.

OΣ 261 $6^{M}.0$ $6^{M}.5$

$\alpha = 13^{h}\,7^{m}\,15^{s}$, $\delta = +32^{\circ}\,37'$

1896.390	347.6	1.34
.453	346.9	1.39
1896.422	347.2	1.36

Apparently rectilinear motion.

Σ1888 ξ *Bootis* . . . . . .

$\alpha = 14^{h}\,46^{m}\,46^{s}$, $\delta = +19^{\circ}\,31'$

1896.384	223.3	2.94
.403	222.9	2.62
.420	221.4	2.71
1896.402	222.5	2.76

Σ1909 44 *Bootis* 5^{M} 6^{M}

$\alpha = 15^{h}\,0^{m}\,31^{s}$, $\delta = +48^{\circ}\,3'$

1896.423	242.7	4.63
.431	240.6	4.65
1896.427	241.6	4.64

Σ1924 $8^{M}.7$ $9^{M}.1$

$\alpha = 15^{h}\,9^{m}\,48^{s}$, $\delta = +26^{\circ}\,8'$

	°	″
1896.442	305.7	15.43
.453	307.2	15.19
.486	305.3	15.19
1896.460	306.1	15.27

Fixed. No measures between 1844 and 1896.

β 351 $8^{M}.5$ 12^{M}

$\alpha = 15^{h}\,11^{m}\,27^{s}$, $\delta = -15^{\circ}\,13'$

1896.491	301.2	10.90
.497	302.8	10.60
1896.494	302.0	10.75

Relatively fixed.

Σ1937 η *Coronae* . . . . . .

$\alpha = 15^{h}\,19^{m}\,4^{s}$, $\delta = +30^{\circ}\,39'$

1896.420	309.1	0.39
.423	314.5	0.46
.431	305.4	0.36
.472	317.0	0.39
1896.436	311.5	0.40

μ^2 *Bootis* $7^{M}.0$ $7^{M}.4$

$\alpha = 15^{h}\,20^{m}\,44^{s}$, $\delta = +37^{\circ}\,43'$

1896.420	80.3	0.72
.423	83.7	0.77
.425	80.7	0.73
.431	81.0	0.80
.444	81.8	0.76
1896.429	81.5	0.76

β 945 $6^{M}.6$ $12^{M}.0$

$\alpha = 15^{h}\,26^{m}\,37^{s}$, $\delta = +57^{\circ}\,47'$

1896.508	31.9	16.11
.510	31.8	15.95
1896.509	31.8	16.03

The principal star has proper motion of 0″.304 in direction of 297°.4. The change in *B* corresponds to this movement.

OΣ 297 $7^{M}.5$ $12^{M}.8$

$\alpha = 15^{h}\,30^{m}\,31^{s}$, $\delta = +25^{\circ}\,21'$

	°	″
1896.508	138.9	5.51
.510	138.0	5.43
1896.509	138.4	5.47

The change of about 8″ in distance since 1845 appears to be due to proper motion.

β 620 . . . . . .

$\alpha = 15^{h}\,40^{m}\,6^{s}$, $\delta = -27^{\circ}\,45'$

A and *B*.

1896.521	176.6	0.69
.524	176.4	0.56
.527	170.4	0.64
1896.524	174.5	0.63

Direct motion in angle.

Σ1969 $8^{M}.0$ $8^{M}.3$

$\alpha = 15^{h}\,39^{m}\,24^{s}$, $\delta = +60^{\circ}\,18'$

1896.497	50.0	0.75
.502	52.7	0.68
1896.500	51.4	0.72

Distance decreasing.

β 810 $8^{M}.6$ $10^{M}.8$

$\alpha = 15^{h}\,47^{m}\,36^{s}$, $\delta = +42^{\circ}\,46'$

1896.497	85.2	0.90
.510	87.6	0.79
.518	85.1	0.76
1896.508	86.0	0.82

Angle and distance decreasing.

Σ1992 $8^{M}.8$ $8^{M}.9$

$\alpha = 15^{h}\,55^{m}\,33^{s}$, $\delta = +11^{\circ}\,57'$

	°	″
1896.453	326.2	5.95
.472	325.1	5.88
.486	326.2	5.83
1896.470	325.8	5.89

Probably without change.

Hv. 75 $7^{M}.8$ $9^{M}.6$

$\alpha = 15^{h}\,56^{m}\,50^{s}$, $\delta = +26^{\circ}\,27'$

1896.486	110.6	47.22
.491	111.3	47.44
1896.488	111.0	47.33

Change from proper motion of about 5″ since 1841.

S 676 ρ *Coronae* 6^{M} $9^{M}.2$

$\alpha = 15^{h}\,57^{m}\,15^{s}$, $\delta = +33^{\circ}\,36'$

1896.486	83.6	80.10
.491	83.9	79.75
.502	83.6	80.11
1896.493	83.7	79.99

The change of 60° in angle is explained by proper motion of principal star

Σ2032 σ *Coronae* 5^{M} 6^{M}

$\alpha = 16^{h}\,10^{m}\,56^{s}$, $\delta = +34^{\circ}\,7'$

1896.420	210.1	4.44
.423	211.0	4.39
.425	211.3	4.35
.502	211.9	4.02
1896.442	211.1	4.30

Σ2026 $8^{M}.7$ $9^{M}.2$

$\alpha = 16^{h}\,11^{m}\,3^{s}$, $\delta = +7^{\circ}\,38'$

1896.497	261.8	0.63
.502	266.0	0.63
.521	261.3	0.63
1896.507	263.0	0.63

Binary. Distance in 1830, 2″.54.

Σ2036 $9^{M}.0$ $10^{M}.1$ 13^{M}

$\alpha = 16^h 10^m 18^s$, $\delta = +72° 49'$

A and B.

	°	"
1896.497	233.2	2.34
.502	234.2	2.51
.521	232.9	2.25
.573	231.7	2.21
1896.523	233.0	2.33

A and C.

1896.521	343.1	. . .
.573	339.4	14.35
.581	339.2	14.19
1896.558	340.6	14.27

Measures of AB discordant, and change uncertain.

OΣ 311 $7^{M}.7$ $10^{M}.8$

$\alpha = 16^h 23^m 25^s$, $\delta = +21° 7'$

1896.442	199.0	7.19
.464	198.2	7.53
.486	198.2	7.30
1896.464	198.5	7.34

The motion appears to be rectilinear.

β 815 $8^{M}.1$ $10^{M}.3$

$\alpha = 16^h 23^m 54^s$, $\delta = +43° 8'$

1896.442	342.4	8.68
.453	341.4	8.41
.510	341.0	8.87
1896.468	341.6	8.65

The change appears to be due to proper motion of principal star.

Σ2075 $8^{M}.2$ $11^{M}.4$

$\alpha = 16^h 26^m 47^s$, $\delta = +80° 16'$

1896.587	320.1	1.20
.623	321.8	1.10
1896.605	321.0	1.15

Motion doubtful.

Σ2057 $9^{M}.3$ $9^{M}.3$

$\alpha = 16^h 27^m 9^s$, $\delta = +19° 30'$

1896.472	267.5	4.92
.480	267.0	4.95
1896.476	267.2	4.94

Fixed.

Σ2058 $9^{M}.2$ $9^{M}.4$ $10^{M}.5$

$\alpha = 16^h 27^m 19^s$, $\delta = +19° 31'$

A and B

1896.480	347.3	2.03
.491	318.0	1.89
1896.486	317.6	1.96

A B and C.

1896.480	137.1	15.95
.491	138.3	15.61
1896.486	137.7	15.78

No measures of AB in the last fifty years. No evidence of change. The faint star has never been measured before.

Σ2080 $8^{M}.0$ $11^{M}.8$

$\alpha = 16^h 35^m 8^s$, $\delta = +38° 32'$

		"
1896.516	26.1	3.15
.518	26.1	3.46
.524	26.4	3.16
.587	25.0	3.28
1896.536	25.9	3.26

But few measures of this pair. Distance steadily diminishing, with but little change in the angle. The components will finally form a close pair.

Δ15 $8^{M}.0$ $8^{M}.3$

$\alpha = 16^h 40^m 57^s$, $\delta = +43° 40'$

1896.423	338.2	0.59
.431	331.7	. . .
.480	337.9	. . .
.497	336.4	0.56
1896.458	336.8	0.58

Probably binary. But the motion to 1892 was apparently rectilinear.

β 627 52 *Herculis* 5^{M} $9^{M}.5$

$\alpha = 16^h 46^m 18^s$, $\delta = +46° 10'$

1896.453	316.7	1.42
.491	319.7	1.78
.494	316.4	2.00
.510	315.9	. . .
.518	318.0	2.06
1896.493	317.3	1.82

Σ2107 6^{M} 8^{M}

$\alpha = 16^h 47^m 53^s$, $\delta = +28° 50'$

1896.521	303.2	0.40
.524	304.2	0.34
.528	304.9	0.30
1896.524	304.1	0.35

Binary. An arc of 155° has been passed over since measures of Σ in 1829.

Küstner 1 $6^{M}.6$ $10^{M}.2$

$\alpha = 16^h 47^m 37^s$, $\delta = +77° 41'$

1896.497	192.8	. . .
.502	192.4	2.93
.527	192.9	2.87
1896.509	192.7	2.90

Change since the measures of β in 1889.

Σ2117 $8^{M}.2$ $10^{M}.8$

$\alpha = 16^h 55^m 42^s$, $\delta = +51° 57'$

1896.573	105.4	1.37
.579	106.3	1.26
1896.576	105.8	1.32

Slow motion in angle. Only 3 measures since 1831.

β 822 $6^{M}.8$ $11^{M}.2$

$\alpha = 16^h 59^m 31^s$, $\delta = +19° 49'$

	°	"
1896.518	229.0	1.67
.521	225.1	. . .
.524	226.7	1.53
.527	231.6	1.71
1896.522	228.1	1.64

No evidence of motion since 1881.

β 357 $8^{M}.0$ $9^{M}.3$

$\alpha = 17^h 0^m 49^s$, $\delta = +10° 41'$

1896.453	297.2	1.18
.499	298.6	1.24
.579	298.3	1.18
1896.510	298.0	1.20

Some change in the angle is probable.

β 823 $8^{M}.0$ $9^{M}.2$

$\alpha = 17^h 1^m 30^s$, $\delta = +0° 47'$

1896.453	5.5	0.92
.499	5.6	0.94
.518	4.9	0.98
1896.490	5.3	0.95

Slow direct motion in angle.

β 1118 η *Ophiu.* $4^{M}.0$ $5^{M}.0$

$\alpha = 17^h 4^m 38^s$, $\delta = -15° 36'$

1896.521	262.2	0.38
.524	259.2	0.37
.527	258.0	0.40
1896.524	259.8	0.38

In 1892 β found the angle 270°.0 and distance 1″.36.

OΣ 327 $7^{M}.5$ $7^{M}.7$

$\alpha = 17^h 12^m 16^s$, $\delta = +56° 15'$

1896.573	318.5	0.31
.587	313.5	0.28
1896.580	316.0	0.30

Very few measures. The motion may be rapid.

Σ2150 $9^{M}.3$ $9^{M}.7$

$\alpha = 17^h 16^m 10^s$, $\delta = +1° 40'$

1896.472	196.9	9.40
.480	195.6	9.15
.491	196.7	9.11
1896.481	196.4	9.22

Distance and angle increasing. Only one measure since 1866.

β 47 $8^{M}.1$ $10^{M}.8$

$\alpha = 17^h 55^m 38^s$, $\delta = -10° 14'$

1896.527	274.0	1.76
.554	273.3	1.65
.579	272.3	1.51
1896.553	273.2	1.64

70 *Ophiuchi* $4^{M}.0$ $5^{M}.5$

$\alpha = 18^h 0^m 23^s$, $\delta = +2° 32'$

	°	"
1896.529	289.7	2.22
.705	288.0	2.20
.768	288.1	2.21
.787	288.9	2.20
.790	288.2	2.15
.822	288.6	2.15
1896.734	288.6	2.19

β 132 $7^{M}.0$ $7^{M}.2$

$\alpha = 18^h 5^m 18^s$, $\delta = -19° 52'$

1896.444	222.2	0.89
.521	224.8	0.86
.554	226.6	1.07
1896.506	224.5	0.94

Retrograde motion.

β 463 $9^{M}.0$ $9^{M}.8$

$\alpha = 18^h 11^m 55^s$, $\delta = -16° 55'$

1896.444	102.4	1.88
.513	102.6	. . .
.518	99.9	2.46
.521	100.3	2.31
1896.499	101.3	2.22

Σ2311 $8^{M}.8$ $9^{M}.6$

$\alpha = 18^h 17^m 24^s$, $\delta = +11° 23'$

1896.464	157.7	6.41
.491	159.7	5.72
.497	158.9	5.88
1896.484	158.8	6.00

In 1830 distance was 8″.65, and angle 170°.7. Motion probably rectilinear.

OΣ 347 $7^{M}.0$ $11^{M}.5$

$\alpha = 18^h 19^m 54^s$, $\delta = +7° 11'$

1896.513	346.5	3.28
.524	346.3	3.01
.529	346.8	3.10
1896.522	346.5	3.13

No measures since 1868. Angle and distance are diminishing.

β 134 $7^{M}.7$ $9^{M}.7$

$\alpha = 18^h 22^m 34^s$ $\delta = +46° 50'$

1896.491	141.0	1.08
.499	137.8	1.17
.573	133.1	1.19
1896.521	137.3	1.15

No material change.

Σ2369 $7^{M}.7$ $8^{M}.3$

$\alpha = 18^h 38^m 54^s$, $\delta = +2° 31'$

1896.444	93.2	1.17
.480	91.8	1.09
.491	93.1	1.12
1896.472	92.7	1.13

The components are slowly approaching.

β 645 $7^{M}.3$ $11^{M}.8$

$\alpha = 18^h\,38^m\,53^s$, $\delta = +19^\circ\,22'$

	°	″
1896.551	300.4	9.33
.579	304.2	9.59
.606	306.1	9.68
1896.580	303.6	9.53

Σ2393 $7^{M}.5$ $9^{M}.5$

$\alpha = 18^h\,41^m\,47^s$, $\delta = +38^\circ\,12'$

1896.448	24.3	13.40
.464	24.2	. . .
.491	24.8	13.37
1896.469	24.4	13.38

The stars are gradually separating. No measure since 1865.

β 648 $6^{M}.0$ $8^{M}.8$

$\alpha = 18^h\,53^m\,15^s$, $\delta = +32^\circ\,46'$

1896.554	233.6	1.65
.573	233.4	1.35
.579	233.1	1.36
1896.569	233.4	1.45

The companion has moved about 80° since 1878.

Σ2438 $7^{M}.5$ $7^{M}.5$

$\alpha = 18^h\,55^m\,49^s$, $\delta = +58^\circ\,6'$

1896.448	22.5	0.32
.524	32.0	0.34
.527	20.5	0.38
1896.500	25.0	0.35

Rapid binary.

Σ2434 $8^{M}.2$ $9^{M}.2$

$\alpha = 18^h\,57^m\,35^s$, $\delta = -0^\circ\,51'$

B and *C*

1896.444	59.0	1.25
.491	59.7	1.38
1896.468	59.4	1.32

Certainly binary.

β 52 $8^{M}.2$ $9^{M}.6$ $11^{M}.5$

$\alpha = 18^h\,59^m\,43^s$, $\delta = +25^\circ\,53'$

A and *B*

1896.579	300.3	51.95
.581	299.6	51.81
.661	299.5	51.98
1896.607	299.8	51.91

B and *C*.

1896.579	174.4	8.97
.581	167.4	8.34
.661	171.1	8.65
1896.607	171.0	8.65

No other measures.

β 140 $7^{M}.9$ $10^{M}.9$ $11^{M}.6$

$\alpha = 19^h\,11^m\,18^s$, $\delta = -11^\circ\,9'$

A and *B*.

1896.614	324.0	37.37
.620	324.9	37.46
.759	325.7	37.07
1896.664	324.9	37.30

B and *C*.

	°	″
1896.614	209.1	7.66
.620	208.2	7.86
.759	208.5	7.46
1896.664	208.6	7.66

Distance increasing.

β 142 $7^{M}.7$ $8^{M}.0$

$\alpha = 19^h\,22^m\,37^s$, $\delta = -12^\circ\,21'$

1896.480	334.6	1.56
.521	332.9	1.56
1896.500	333.8	1.56

Slow direct motion in angle.

Σ2614 $9^{M}.0$ $9^{M}.7$

$\alpha = 19^h\,12^m\,30^s$, $\delta = +88^\circ\,10'$

1896.581	234.7	1.62
.587	235.7	1.58
.601	236.0	1.64
1896.590	235.5	1.61

The only measures since Σ are by Δ in 1869. The precession since Σ's measure is —10°, while the motion is —18°.

β 653 $4^{M}.5$ $13^{M}.0$ $13^{M}.0$

$\alpha = 19^h\,29^m\,10^s$, $\delta = +7^\circ\,11'$

A and *B*.

1896.494	278.5	26.67
.499	278.0	26.45
1896.496	278.2	26.56

A and *C*.

1896.494	288.9	26.68
.499	289.1	26.47
1896.496	289.0	26.58

Considerable change since the first measures of β in 1878, probably due to proper motion of *A*.

β 655 $8^{M}.0$ $8^{M}.9$ $8^{M}.2$

$\alpha = 19^h\,30^m\,2^s$, $\delta = +63^\circ\,7'$

A and *B*.

1896.565	288.7	23.67
.581	288.6	23.83
1896.573	288.6	23.75

A and *C*.

1896.565	275.7	50.56
.581	274.7	50.68
1896.573	275.2	50.62

These stars make Σ 2549. *C* is a close pair.

Σ2553 $8^{M}.0$ $8^{M}.8$

$\alpha = 19^h\,32^m\,4^s$, $\delta = +61^\circ\,50'$

1896.527	97.0	0.96
.543	99.0	0.88
.587	100.1	0.86
1896.552	98.7	0.90

A change of about 20° in angle since Σ.

Σ2564 $8^{M}.2$ $8^{M}.8$

$\alpha = 19^h\,36^m\,2^s$, $\delta = +63^\circ\,36'$

	°	″
1896.513	169.8	9.84
.518	171.3	9.92
1896.516	170.6	9.88

Change in angle and distance, and probably rectilinear motion.

β 829 $8^{M}.0$ $8^{M}.7$

$\alpha = 19^h\,44^m\,1^s$, $\delta = +5^\circ\,30'$

1896.499	310.3	0.74
.538	310.9	0.64
.554	305.6	0.72
.574	307.4	0.77
1896.541	308.6	0.72

Motion, if any, very slow.

Σ2615 $7^{M}.3$ $9^{M}.6$

$\alpha = 19^h\,58^m\,10^s$, $\delta = +8^\circ\,7'$

1896.464	316.6	. . .
.480	316.9	10.35
.491	318.0	10.23
.494	317.3	10.18
1896.482	317.2	10.25

Slow retrograde motion. No measures since 1878.

β 56 $8^{M}.0$ $8^{M}.9$

$\alpha = 19^h\,59^m\,50^s$, $\delta = -4^\circ\,36'$

1896.494	167.0	1.55
.499	165.2	1.55
.573	164.9	1.54
1896.522	165.7	1.55

Probably no sensible change since 1875.

Σ2649 $7^{M}.8$ $8^{M}.9$

$\alpha = 20^h\,8^m\,22^s$, $\delta = +31^\circ\,46'$

1896.540	151.8	24.13
.579	151.7	24.18
1896.560	151.8	24.16

Distance slowly decreasing.

S 380 σ *Capric.* $6^{M}.0$ $8^{M}.8$

$\alpha = 20^h\,13^m\,38^s$, $\delta = -19^\circ\,26'$

1896.625	177.8	55.70
.650	178.1	55.71
.661	177.8	55.81
1896.645	177.9	55.74

HERSCHEL made the distance 50″.12 in 1782. The above results are identical with the measures of β in 1881.

β 664 $7^{M}.5$ $12^{M}.2$

$\alpha = 20^h\,19^m\,36^s$, $\delta = +5^\circ\,11'$

1896.661	286.3	. . .
.759	287.6	8.76
1896.710	287.0	8.76

OΣ413 λ *Cygni* $5^{M}.3$ $6^{M}.5$

$\alpha = 20^h\,43^m\,31^s$, $\delta = +36^\circ\,7'$

	°	″
1896.491	65.0	. . .
.494	64.0	0.58
.543	61.6	0.71
.579	61.8	0.57
.765	61.5	. . .
1896.574	62.8	0.62

F.P.L. $8^{M}.8$ $10^{M}.0$

$\alpha = 20^h\,48^m\,38^s$, $\delta = -11^\circ\,18'$

1896.573	287.7	1.21
.587	296.0	1.21
1896.580	291.8	1.21

This star is Lamont 3427.

Σ2746 $7^{M}.8$ $8^{M}.5$

$\alpha = 20^h\,58^m\,0^s$, $\delta = +38^\circ\,52'$

1896.499	295.2	1.02
.538	291.6	1.13
.543	296.3	1.10
1896.527	294.4	1.08

Slow motion in angle.

Nova $9^{M}.0$ $10^{M}.6$

$\alpha = 20^h\,58^m\,12^s$, $\delta = +38^\circ\,50'$

1896.538	194.3	2.01
.573	193.5	2.78
.587	193.0	2.12
.601	190.6	2.50
1896.575	192.8	2.35

This star follows Σ 2746 $11^s.9$, and is south 1′ 36″.

Σ2759 $8^{M}.0$ $8^{M}.8$

$\alpha = 21^h\,2^m\,19^s$, $\delta = +32^\circ\,3'$

1896.494	324.4	16.04
.538	324.3	16.07
1896.516	324.1	16.06

Distance increasing. Only two measures since 1830.

β 838 $8^{M}.0$ $9^{M}.9$

$\alpha = 21^h\,15^m\,52^s$, $\delta = +2^\circ\,42'$

1896.573	99.1	1.83
.661	97.3	1.47
.759	99.8	1.67
1896.664	98.7	1.66

Slow angular motion.

H 281 $8^{M}.7$ $9^{M}.2$

$\alpha = 21^h\,16^m\,24^s$, $\delta = +16^\circ\,19'$

1896.540	334.3	14.12
.573	335.7	13.99
.768	335.9	14.14
1896.627	335.3	14.08

H. made the distances 17″.52 in 1829, and the Cin. observers 13″.50 in 1879. No other measures

S 790 $6^{M}.0$ $10^{M}.5$ $9^{M}.1$

$\alpha = 21^{h}\,21^{m}\,42^{s}$, $\delta = +36^\circ\,14'$

A and *B*.

	°	″
1896.598	29.8	33.01
.625	30.5	32.73
1896.612	30.2	32.87

A and *C*.

1896.598	97.9	54.11
.625	98.4	53.68
1896.612	98.2	53.90

Careful search was made in this neighborhood, but no other double star found. South found 1825.27 258°.6 40″.30 2 m. No other measures.

Σ 2799 $6^{M}.6$ $6^{M}.8$

$\alpha = 21^{h}\,24^{m}\,1^{s}$, $\delta = +10^\circ\,39'$

1896.494	118.1	1.65
.499	121.6	1.47
.538	120.2	1.60
1896.510	120.0	1.57

Angular movement of 30° since 1830. Stars equal in Σ.

H 3040 $6^{M}.0$ $9^{M}.0$

$\alpha = 21^{h}\,31^{m}\,29^{s}$, $\delta = -19^\circ\,55'$

1896.623	47.2	68.44
.650	48.1	68.48
.655	47.5	68.59
1896.643	47.6	68.50

No change according to the measures of β in 1881.

F.P.L. $8^{M}.5$ $9^{M}.8$

$\alpha = 21^{h}\,38^{m}\,8^{s}$, $\delta = -11^\circ\,35'$

1896.601	276.4	1.31
.655	272.6	. . .
.784	271.9	1.09
1896.680	273.6	1.20

This star is Lamont 3735.

Σ 2825 $7^{M}.8$ $8^{M}.3$

$\alpha = 21^{h}\,41^{m}\,47^{s}$, $\delta = +0^\circ\,23'$

	°	″
1896.499	113.0	0.84
.538	114.6	1.07
.543	113.7	1.03
1896.527	113.8	0.98

Slow angular movement.

Σ 2828 $8^{M}.1$ $9^{M}.0$

$\alpha = 21^{h}\,44^{m}\,27^{s}$, $\delta = +2^\circ\,55'$

A and *B*.

1896.540	141.1	27.54
.631	142.5	26.95
.644	141.5	27.14
1896.605	141.7	27.21

Distance increasing. No change in *BC*.

β 75 $8^{M}.0$ $8^{M}.2$

$\alpha = 21^{h}\,50^{m}\,39^{s}$, $\delta = +10^\circ\,25'$

1896.655	38.0	1.06
.661	37.4	1.20
.759	38.0	1.26
1896.692	37.8	1.17

S 800 $6^{M}.2$ $7^{M}.2$

$\alpha = 21^{h}\,50^{m}\,55^{s}$, $\delta = +62^\circ\,9'$

1896.538	146.0	62.91
.540	145.4	62.76
1896.539	145.7	62.84

No other measures since 1824. Apparently fixed.

S 808 $8^{M}.0$ $9^{M}.0$

$\alpha = 22^{h}\,20^{m}\,21^{s}$, $\delta = -20^\circ\,45'$

1896.543	151.5	6.86
.631	150.1	6.76
1896.587	150.8	6.81

No other measures since 1825. Probably unchanged.

β 709 $8^{M}.3$ $9^{M}.4$

$\alpha = 22^{h}\,36^{m}\,28^{s}$, $\delta = -3^\circ\,5'$

	°	″
1896.784	4.6	2.20
.814	7.2	2.00
.822	4.3	1.92
1896.807	5.4	2.04

*O*Σ 477 $7^{M}.3$ $11^{M}.0$

$\alpha = 22^{h}\,39^{m}\,5^{s}$, $\delta = +45^\circ\,30'$

1896.631	191.2	4.55
.784	185.5	4.26
.814	194.4	4.55
1896.743	190.4	4.45

Decided change. Distance in 1846, 9″.60. Motion appears to be rectilinear.

H 301 ξ *Pegasi* $4^{M}.0$ $12^{M}.3$

$\alpha = 22^{h}\,41^{m}\,42^{s}$. $\delta = +11^\circ\,39'$

1896.631	110.1	12.24
.661	111.7	12.35
.822	109.8	. . .
1896.705	110.5	12.30

The companion has same proper motion as the large star.

*O*Σ 536 . . . . . .

$\alpha = 22^{h}\,53^{m}\,29^{s}$, $\delta = +8^\circ\,49'$

1896.540	158.2	0.43
.543	182.8	0.36
.565	170.4	0.29
1896.549	170.5	0.36

H 1842 β *Pegasi* $3^{M}.7$ $10^{M}.6$

$\alpha = 22^{h}\,58^{m}\,54^{s}$, $\delta = +27^\circ\,32'$

1896.631	208.5	103.04
.655	209.6	102.81
.768	209.4	102.76
1896.685	209.2	102.87

The only other measure of this is by β in 1879, when the distance was 98″.38. The change is due to the proper motion of the large star.

*O*Σ 489 π *Cephei* $5^{M}.8$ $7^{M}.8$

$\alpha = 23^{h}\,5^{m}\,19^{s}$, $\delta = +74^\circ\,50'$

	°	″
1896.751	32.9	0.80
.822	38.6	1.01
1896.786	35.8	0.90

Probably binary, but motion very slow.

H 5394 96 *Aqua.* $5^{M}.2$ $10^{M}.5$

$\alpha = 23^{h}\,14^{m}\,12^{s}$, $\delta = -5^\circ\,40'$

1896.759	21.5	10.53
.768	21.3	10.65
.771	21.1	10.52
1896.766	21.3	10.57

Very little relative change, and the proper motion of *A* appears to belong to *B*.

β 720 72 *Pegasi* $6^{M}.0$ $6^{M}.5$

$\alpha = 23^{h}\,29^{m}\,0^{s}$, $\delta = +30^\circ\,47'$

1896.565	167.0	0.39
.631	146.5	0.40
.809	157.4	0.38
1896.668	157.0	0.39

The angular motion is 30° since 1878.

H_0 204 $8^{M}.0$ $9^{M}.9$

$\alpha = 23^{h}\,47^{m}\,9^{s}$, $\delta = +28^\circ\,2'$

1896.759	355.9	5.90
.784	355.8	5.91
.790	356.9	5.79
1896.778	356.2	5.87

Sh. 358 $7^{M}.8$ $8^{M}.9$

$\alpha = 23^{h}\,49^{m}\,13^{s}$, $\delta = +31^\circ\,21'$

1896.811	329.5	37.59
.814	328.9	37.35
1896.812	329.2	37.47

The only measures since 1822 are by β in 1881. Probably fixed.

MICROMETRICAL MEASURES OF F. 70 *OPHIUCHI*, WITH REMARKS ON THE PERTURBATION OF THE SYSTEM,

By T. J. J. SEE.

The following micrometrical measures of F. 70 *Ophiuchi* have been secured with the 24-inch Refractor:

AB:

t	θ_0	ρ_0	No. of Micr. Settings
	°	″	
1897.381	284.1	2.00	6–6
1897.383	283.0	2.10	6–6
1897.386	282.6	1.96	6–6
1897.427	282.8	2.04	4–4
1897.430	283.4	2.09	4–5
1897.463	283.0	1.94	6–6
1897.415	283.15	2.022	6*n* SEE

BC:

t	θ_0	ρ	No. of Micr. Settings
	°	″	
1897.425	206.3	53.49	8–7
1897.427	206.1	53.36	8–8
1897.430	206.1	53.30	4–8
1897.463	206.1	53.25	8–8
1897.436	206.15	53.35	4*n* SEE

AB:

	°	″	
1897.381	283.6	2.18	6–6
1897.383	283.3	2.17	3–3
1897.386	283.0	2.05	6–6
1897.430	283.0	1.98	4–4
1897.395	283.22	2.095	4*n* COGSHALL

The power used in taking the measures was 750, but in examining the stars I applied powers of 1000 and 1500 respectively. On several of the nights the seeing was most excellent, and on one occasion (May 20) under a power of 1500 I counted at least a dozen diffraction fringes almost perfect and motionless. The images were perfectly round under the highest powers.

Like the measures made at Greenwich by the courtesy of the Astronomer Royal, and elsewhere, these results confirm the perturbation discussed in *A.J.* 363. In accordance with my previous investigations, Mr. Eric Doolittle's careful discussion in *A.J.*, no. 400, shows that no possible orbit will reconcile both angles and distances, and all such attempts in the future had as well be abandoned. It is important that the system should be followed by many observers, in order that measurement alone may determine just what changes are taking place. I have measured the component *C* in order to furnish material for a future determination of the center of gravity of the system (*Researches on the Evolution of the Stellar Systems*, Vol. 1, p. 255).

The system *AB* has no physical connection with the star *C*, and as its orbital motion now amounts to about 10° per year, good annual measures for about five years would probably give a very satisfactory determination of the relative masses. The following measures of *AC* have been obtained by previous observers:

t	θ_0	ρ_0		
	°	″		
1856.63	215.1	87.57	1*n*	Secchi
1878.84	197.8	71.38	3*n*	Hall
1882.79	197.8	65.60	2*n*	Hall
1886.52	200.4	62.50	3*n*	Hall
1889.30	203.3	59.45	2*n*	Burnham

Burnham has shown (*Pub. Lick Obs.*, II, 100) that the system has a proper motion of about 1″.2 in the direction 172°, and hence the position of *C* is becoming each year more favorable for this investigation. The minimum distance of about 30″ will be reached within 40 years.

Lowell Observatory, Flagstaff, Arizona, 1897 *June* 22.

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE VASSAR COLLEGE OBSERVATORY, POUGHKEEPSIE, N. Y.,

BY MARY W. WHITNEY AND CAROLINE E. FURNESS.

1897 Greenwich M.T.	⁎	No. Comp.	Planet — ⁎		Planet's Apparent		log *p*		Obs.
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ	
(362) 1893 *R*.									
h m s			m s	′ ″	h m s	° ′ ″			
Mar. 10 14 15 49	1	11	+1 7.75	+7 16.1	11 14 55.68	+14 4 14.8	*n*9.463	0.647	W
21 16 49 12	2	10	+0 45.60	−2 2.6	11 4 38.75	+14 28 16.9	8.984	0.608	W
28 16 51 26	3	10	+0 29.11	+6 16.9	10 59 1.78	+14 33 31.0	9.214	0.614	W
(303) *Josephina*.									
Mar. 10 18 14 4	4	10	−0 55.70	+8 33.5	12 9 11.40	− 3 42 51.8	8.699	0.797	F
28 19 0 46	5	8	+1 5.31	+0 16.7	11 55 6.09	− 2 44 57.3	9.448	0.785	F
29 13 43 48	5	9	+0 29.69	+2 54.0	11 54 30.47	− 2 42 20.1	*n*9.442	0.785	F
(190) *Ismene*.									
Mar. 28 17 44 37	6	10	+0 25.90	−2 13.6	11 56 58.69	+ 1 3 48.1	9.177	0.759	F
29 13 25 45	6	11	−0 2.38	+2 2.3	11 56 30.41	+ 1 8 4.0	*n*9.486	0.760	F
Apr. 1 15 38 34	7	8	+1 45.69	−2 58.7	11 54 45.08	+ 1 23 22.4	*n*8.742	0.755	F
(324) *Bamberga*.									
Mar. 28 18 22 30	8	11	+0 8.54	−2 42.2	12 6 51.96	−11 18 35.0	9.309	0.839	W
29 15 49 37	8	6	−0 37.03	+0 53.9	12 6 6.39	−11 14 59.0	*n*8.902	0.846	W
30 15 36 28	8	10	−1 27.39	+4 55.6	12 5 16.03	−11 10 57.3	*n*8.982	0.845	W
(123) *Brunhild*.									
Mar. 31 15 56 15	9	10	+0 16.88	+9 51.2	12 40 16.18	−14 6 23.8	*n*9.079	0.859	F
Apr. 1 16 11 29	10	8	+0 40.16	−0 49.0	12 39 22.93	−14 1 51.1	*n*8.902	0.861	F
2 14 59 9	10	11	−0 9.97	+3 34.4	12 38 32.80	−13 57 27.8	*n*9.315	0.851	F
(146) *Lucina*.									
Apr. 20 15 59 44	11	8	+0 51.84	−3 14.7	14 12 55.71	+ 5 12 6.1	*n*9.129	0.721	W
21 14 31 49	11	13	+0 0.35	−1 51.0	14 12 4.23	+ 5 13 29.9	*n*9.441	0.729	W
28 16 14 55	12	8	+1 18.26	−8 47.6	14 5 36.45	+ 5 18 1.4	*n*8.509	0.718	W

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	11 13 45.13	+2.80	+13 57 13.7	−15.0	⅓ (Glas. I, 2918 + Glas. II, 959 + Schj. 4108)
2	11 3 50.32	+2.83	+14 30 33.5	−14.0	Bonn VI, +14°2350
3	10 58 29.83	+2.84	+14 27 27.6	−13.5	DM. +14°2337 comp. micr. with Paris 13,536
4	12 10 4.53	+2.57	− 3 51 8.3	−17.0	½ (Munich I, 7811 + Munich II, 4353)
5	11 53 58.06	+2.72	− 2 44 56.2	−17.8	½ (Radcliffe (1890) 3109 + Paris 14,633)
6	11 56 30.04	+2.75	+ 1 6 19.4	−17.7	Boss. Albany A.G.C. 4398
7	11 52 56.66	+2.73	+ 1 26 38.6	−17.5	Boss. Albany A.G.C. 4385
8	12 6 40.73	+2.69	−11 15 31.4	−18.5	S.DM. −11°3254, Camb., Mass., Zones; 3 obs.
9	12 39 56.58	+2.72	−14 15 56.1	−18.9	Microm. comp. with S.DM. −14°3568,*
10	12 38 40.05	+2.72	−14 0 43.2	−18.9	S.DM. −13°3588, micr. comp. with −14°3568
11	14 12 0.93	+2.94	+ 5 15 40.2	−19.4	Schjellerup 5085
12	14 4 15.19	+3.00	+ 5 27 8.8	−19.8	Schjellerup 5045

* Cambridge, Mass.: 3 observations.

MAXIMUM OF 2815 *U GEMINORUM.*

By J. A. PARKHURST.

Rev. J. G. Hagen's prediction, in *A.J.* no. 400, that the June maximum of this star could not be observed, led me to make extra effort to see it. After looking for it every clear evening in May, I found it bright June 7. To make the identification certain, 5 observations were made between 14h 30m and 15h 0m, Gr. M.T. The magnitude found from the comparisons was 9.6, and as the comparison-stars down to 11M.2, Baxendell's scale, were seen, I have no doubt of the reality of the maximum, in spite of the low altitude and bright twilight. June 11 the variable could not be seen, the limit being about 10M on the same scale.

Marengo, Ill., 1897 *June* 15.

OBSERVATIONS OF COMET 1896 VI (= 1889 V),

MADE AT THE LICK OBSERVATORY OF THE UNIVERSITY OF CALIFORNIA,

By WILLIAM J. HUSSEY.

Mt. Hamilton M.T.		*	No. Comp.	☄ − *		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
1896	h m s			m s	′ ″	h m s	° ′ ″		
Oct. 6	10 31 17	26	d8, 8	−0 6.12	−4 51.7	22 8 28.36	−16 46 35.6	9.264	0.841
7	9 48 7	26	d8, 8	+0 5.25	+2 18.4	22 8 39.71	−16 39 25.6	9.015	0.848
	9 59 10	26	d8, 8	+0 5.35	+2 22.0	22 8 39.81	−16 39 22.0	9.101	0.847
	10 10 1	26	d8, 8	+0 5.36	+2 25.3	22 8 39.82	−16 39 18.7	9.171	0.846
8	10 30 17	27	8, 8	+1 9.09	−3 45.4	22 8 53.56	−16 31 37.1	9.292	0.810
9	9 12 5	28	d8	+0 4.65	. . .	22 9 9.25	. . .	8.632	. .
	9 23 23	28	4	. . .	−5 10.6	. . .	−16 24 21.6	. .	0.848
12	10 11 21	29	11, 8	+1 11.13	+4 56.2	. . .	. . .	9.271	0.838
28	10 19 28	30	4	. . .	−0 9.7	. . .	−13 31 39.9	. .	0.875
	10 50 24	30	d6	+0 28.77	. . .	22 20 6.88	. . .	9.467	. .
29	8 35 12	31	d7, 8	+0 14.87	−2 37.0	22 20 55.15	−13 22 6.2	9.019	0.829
Nov. 1	8 59 23	32	12, 8	+1 39.99	−2 33.7	22 23 39.64	−12 50 18.4	9.228	0.822
	8 59 23	33	12	+1 26.81	. . .	22 23 39.51	. . .	9.228	. .
2	8 34 24	34	d8	−0 8.79	. . .	22 24 36.44	. . .	9.384	. .
	8 42 45	34	d6	. . .	+4 4.7	. . .	−12 39 37.7	. .	0.811
Dec. 2	8 35 59	35	d8, 8	+0 8.35	−3 26.8	23 2 56.42	− 6 37 20.2	9.439	0.783
6	8 59 32	37	8, 6	−4 55.33	−2 51.7	23 9 8.59	− 5 44 2.7	9.504	0.763
7	9 7 54	38	8, 6	−1 18.86	+4 27.5	23 10 43.90	− 5 30 32.6	9.534	0.759
1897 Jan. 1	9 9 29	39	1	. . .	+4 4.6	. . .	+ 0 16 4.7	. .	0.727
4	8 30 42	40	d8, 8	+0 6.21	−2 33.7	23 58 29.04	+ 0 58 14.6	9.571	0.719
	8 47 52	40	5	. . .	−2 23.2	. . .	+ 0 58 25.1	. .	0.720
	8 47 52	41	5	. . .	+0 31.4	. . .	+ 0 58 27.2	. .	0.720
Feb. 25	7 38 28	42	d4	. . .	−3 48.4	. . .	+12 50 17.0	. .	0.657
	7 55 57	42	d8	−0 6.93	. . .	1 38 12.52	. . .	9.228	. .

Mean Places for 1896.0 and 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
26	22 8 30.26	+4.22	−16 42 1.1	+17.2	DM. −16°6044, Tucker, Merid. Circle Obs. (2)
27	22 7 40.29	+4.18	−16 28 8.7	+17.0	Weiss's Argelander 17275
28	22 9 0.12	+4.18	−16 19 28.2	+17.2	Gould, A.G. Catal. 30392
29	22 8 53.7	+4.15	−16 5.1	+17.1	DM. −16°6045
30	22 19 34.15	+3.96	−13 31 47.9	+17.7	Yarnall–Frisby 10112
31	22 20 36.33	+3.95	−13 19 47.0	+17.8	Weisse's Bessel 22^h388
32	22 21 55.75	+3.90	−12 48 2.5	+17.8	Schjellerup 9181
33	22 22 8.81	+3.89	−12 48 47.2	+17.6	Santini 2108
34	22 24 41.34	+3.89	−12 44 0.3	+17.9	12^M connected with ✱32
35	23 2 44.45	+3.62	− 6 34 13.8	+20.4	11^M connected with ✱36
36	23 5 16.51	+3.63	− 6 31 28.0	+20.7	Stone, Radcliffe Catal. 6198
37	23 11 0.28	+3.64	− 5 41 32.3	+21.3	Stone, Radcliffe Catal. 6237
38	23 11 59.14	+3.62	− 5 35 21.3	+21.2	DM. −5°5962, connected with ✱37
39	23 49 22.82	+0.43	+ 0 11 57.1	+ 3.0	Schjellerup 9914
40	23 58 22.37	+0.46	+ 1 0 44.9	+ 3.4	Yarnall–Frisby 10926
41	23 59 29.94	+0.47	+ 0 57 52.1	+ 3.4	Yarnall–Frisby 10934
42	1 38 19.06	+0.39	+12 53 59.1	+ 6.3	14^M connected with ✱43
43	1 38 26.27	+0.39	+12 56 51.9	+ 6.3	B.B. VI. +12°221

The above observations are a continuation of the series published in *A.J.* 381 and 388. The observations of Oct. 6, 9 and 28 were made with the 12-inch, and the others with the 36-inch telescope. *d* indicates that $\Delta\alpha$ and $\Delta\delta$ were measured directly with the micrometer; in other cases they were obtained by transits. The observations of Oct. 7 were made under exceptionally favorable circumstances, and are entitled to great weight. Professor TUCKER has kindly determined the position of the comparison-star for this date with the meridian-circle. The positions of ✱31, as given by WEISSE'S BESSEL and SANTINI, differ considerably. A meridian-circle determination of the position of ✱38 is desirable. The declination of ✱39 as given by WEISSE'S BESSEL is 1′ too large. $\Delta\alpha$ for the observation of Sept. 5 (*A.J.* 388) should read $+1^m 27^s.39$. In reducing the observations the values of one revolution of the micrometer-screws have been taken as follows: 14″.059 for the 12-inch, and 9″.907 for the 36-inch telescope. From transits of circumpolar stars I have obtained for the latter 9″.912, and in the same way Professor AITKEN has obtained 14″.066 for the former. Since the differences are too slight to influence the results appreciably I have preferred to use the old values as determined by BARNARD and BURNHAM.

In July, August, September and October, I searched carefully, at every opportunity, for the companions which accompanied this comet in 1889, without success. To aid in the search I computed an ephemeris for the companion *C* from elements obtained by applying the differences between the elements of the components *A* and *C* in 1889 (*A.J.* X, 153, 161), to BAUSCHINGER'S elements of *A* with the perturbations as brought up to 1896 by POOR, and finally corrected for the difference between the observed and computed places of *A*. In the course of this search many faint, uncatalogued nebulas were seen; they were especially numerous in the region through which the comet passed in September and October.

Lick Observatory, University of California, 1897 *May* 20.

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN., WITH A 4½-INCH REFRACTOR,

BY A. W. QUIMBY.

1897	Time	New Grs.	Total		Fac. Grs.	Def.	1897	Time	New Grs.	Total		Fac. Grs.	Def.	1897	Time	New Grs.	Total		Fac. Grs.	Def.
			Grs.	Spots						Grs.	Spots						Grs.	Spots		
Jan. 1	8	–	3	8	–	poor	Jan. 16	12	2	3	10	3	poor	Jan. 30	9	2	6	24	1	good
3	12	1	3	10	–	poor	18	8	–	3	15	3	fair	31	9	–	5	26	1	fair
4	1	–	3	23	1	poor	19	3	3	6	23	3	fair	Feb. 1	10	–	5	27	1	fair
5	11	–	4	48	2	fair	20	10	–	3	27	3	poor	3	10	–	4	58	1	fair
6	9	–	4	50	2	fair	21	8	–	3	22	3	poor	4	9	–	4	57	2	fair
7	9	–	4	88	2	fair	22	8	–	3	23	3	poor	5	9	–	4	44	2	fair
8	9	–	2	82	2	fair	23	8	–	3	25	3	poor	7	1	–	4	19	1	fair
9	9	–	2	134	2	good	25	8	1	3	7	2	poor	9	2	1	2	9	2	fair
10	9	–	2	106	3	fair	26	8	–	3	3	2	poor	10	8	–	2	5	2	poor
11	8	1	2	86	3	poor	27	8	–	1	1	–	poor	11	8	–	2	10	2	fair
12	8	–	2	69	2	fair	28	10	1	2	4	2	poor	13	8	–	1	6	4	fair
13	8	1	2	27	2	poor	29	9	2	4	8	3	fair	14	1	1	2	6	–	fair

1897	Time	New Grs.	Total		Fac. Grs.	Def.
			Grs.	Spots		
Feb. 15	1	–	2	7	–	fair
16	2	–	1	7	1	fair
17	8	–	1	6	2	fair
18	8	–	1	8	1	fair
19	8	–	1	1	2	fair
20	8	–	1	1	1	poor
21	8	–	1	1	1	poor
23	9	2	2	5	2	fair
24	8	1	3	12	2	fair
25	8	–	3	14	1	fair
26	8	1	4	19	1	fair
27	8	1	5	19	1	fair
28	8	–	5	15	2	fair
Mar. 1	8	–	1	6	–	v. poor
2	8	–	5	33	1	fair
3	4	–	4	20	2	fair
4	10	–	4	12	1	fair
7	9	–	2	3	1	poor
8	3	3	5	10	2	fair
9	10	–	5	7	2	poor
10	3	–	4	6	2	fair
11	8	–	3	3	3	fair
12	3	–	3	9	1	good
13	8	–	2	4	2	fair
14	3	–	1	3	–	poor
15	8	1	2	34	2	fair
16	8	–	2	26	1	fair
17	7	–	2	15	1	fair
*21	7	1	1	1	2	fair
*22	7	–	1	1	3	fair
*23	7	–	1	1	2	fair
Mar. 24	1	1	2	6	2	fair
25	8	–	2	15	1	fair
26	8	1	2	3	2	fair
27	8	–	2	4	1	fair
28	8	1	3	4	1	fair
29	8	1	4	7	1	fair
30	3	1	4	8	4	fair
31	8	–	4	5	2	fair
Apr. 1	8	1	5	17	4	fair
2	8	–	4	28	2	fair
3	8	1	5	22	2	fair
4	8	2	6	16	2	fair
5	3	–	6	27	2	good
6	7	1	7	28	3	good
7	8	–	7	50	3	good
8	8	–	7	34	3	good
10	8	1	6	30	2	fair
11	5	–	6	30	2	fair
12	4	4	4	29	1	fair
13	8	–	4	17	1	poor
14	8	1	4	11	2	fair
15	5	–	2	2	2	fair
16	8	–	3	6	2	fair
17	8	–	1	1	2	poor
18	8	1	2	7	4	fair
19	4	–	2	10	3	fair
20	11	–	2	6	1	poor
21	8	–	2	6	2	fair
22	8	–	1	1	3	fair
May 27	7	1	3	6	2	fair
28	7	–	2	7	3	fair
May 29	7	–	2	8	3	fair
30	7	–	2	17	2	good
31	5	–	2	10	–	fair
June 1	7	–	2	10	–	fair
2	7	–	2	7	–	fair
3	2	–	2	6	2	fair
4	7	–	2	3	1	fair
5	7	–	2	3	2	fair
6	7	–	1	1	2	poor
9	7	–	–	–	–	poor
10	7	–	–	–	1	fair
11	7	–	–	–	1	fair
12	9	1	1	6	1	fair
13	5	–	1	16	–	poor
14	7	–	1	14	1	fair
15	6	–	1	2	1	poor
16	7	–	1	1	1	poor
17	3	–	–	–	–	poor
18	7	–	–	–	–	fair
19	7	–	–	–	1	fair
20	6	1	1	1	1	fair
21	7	1	2	2	–	fair
22	7	1	3	6	2	fair
23	7	–	2	7	1	fair
24	7	–	1	1	1	poor
25	10	–	2	5	–	fair
26	7	–	2	4	1	good
27	7	–	2	4	1	fair
28	7	–	2	4	1	fair
29	7	–	2	9	1	fair
30	7	–	2	11	1	fair

* $2\frac{1}{4}$-inch refractor; 36-inch focus.

COMET *a* 1897 = D'ARREST'S PERIODIC COMET.

A telegram from Professor Holden announces the rediscovery of this comet by Perrine on June 28 in the position,

$$1897 \text{ June } 28.9764 \text{ Gr. M.T.} \qquad \alpha = 2^{\mathrm{h}}\ 1^{\mathrm{m}}\ 24^{\mathrm{s}}.6. \qquad \delta = +6^\circ\ 13'\ 31''$$

thus showing the correction to Mr. Leveau's ephemeris, *A.J.* 394, to be

$$\Delta\alpha = -3^{\mathrm{m}}\ 57^{\mathrm{s}} \quad , \quad \Delta\delta = -4'.3.$$

CORRIGENDA.

No. 388, p. 28, in δ of nebula 28, *for* 26° *put* 36°.
No. 405, p. 164, col. 1, line 35, *for* constants *put* octants.
" " " 166, col. 1, bottom line, *for* zero-equator *put* zero-ecliptic.
No. 405, p. 166, insert seconds-mark *s* at top of col. "n_8" of table.
" " " 167, col. 2, line 24, *for* ζ *put* ζ_0.

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Measures of Double Stars, by Prof. F. P. Leavenworth.
Micrometrical Measures of F. 70 Ophiuchi, with Remarks on the Perturbation of the System, by Dr T. J. J. See.
Observations of Minor Planets, by Prof. Mary W. Whitney and Miss Caroline E. Furness.
Maximum of 2815 *U* Geminorum, by Mr. J. A. Parkhurst.
Observations of Comet 1896 VI (= 1889 V), by Prof. William J. Hussey.
Sunspot Observations, by Rev. A. W. Quimby.
Comet *a* 1897 = D'Arrest's Periodic Comet.
Corrigenda.

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OBSERVED PLACES OF 310 EPHEMERIS-STARS,

BY R. H. TUCKER.

This list contains all of the stars of the various Ephemerides, which are not in the *Berliner Jahrbuch* down to −40° declination. They have been reduced, with a list of *B.J.* equatorial stars as fundamental. The observed places of these fundamental stars, as well as *B.J.* circumpolars, and zenith-stars from the same, are included in the list. The place of any one of the *B.J.* stars, however, is essentially independent of its use in the determination of the constants of reduction.

Without entering here upon any discussion of the different systems, the places of the list should be an approach towards uniformity; which is a prime requisite in the use of an extended list of stars. The observed places may be reduced to a more nearly perfect system, by the direct application of final corrections to the fundamental stars, when these corrections shall have been derived.

In the meantime these places should facilitate the investigation of accidental errors; the existence of which is evident from comparison of the ephemeris differences.

In the observation of *B.J.* stars, such were included as were required for the derivation of constants of reduction, without aiming to secure uniformity either in number or distribution of observations; in general eight fundamentals and six azimuth-stars were obtained for a night of four hours. The stars not in *B.J.* have been observed 4 times in each position of the instrument, fixed circle east and west; and those above 70° declination have been similarly observed at each culmination, 16 times in all. Abut 3800 full determinations are here included.

The correction for proper motion has been applied in deducing the results of the following list. The value has been taken from the first of the authorities cited. The mean epoch of observation of the list is 1895.1; and the epoch for any star will rarely differ a year from the epoch of reduction, 1895.0. It is not likely that any essential changes would be introduced by the use of other values of proper motion.

Some preliminary discussion of the results of this series has been given in *A.J.* 391 and 398, to which reference may be made. It was then anticipated that full results and details would soon be published.

Circumstances beyond the control of the Observatory have rendered it probable that publication will be very much delayed. And it appears to be proper that the places should be presented now for use in the meantime.

For convenience in the discussion of systematic differences the results of the comparison of the ephemeris-places of the 86 equatorial stars, actually employed as fundamental, are reviewed here.

EPHEMERIS-DIFFERENCES: FUNDAMENTAL STARS.

	$\Delta\alpha$	$\Delta\delta$		
	s	″		
B.J. − A.E.	−0.026	+0.05	50 stars	
B.J. − C.T.	+0.015	−0.22	53 "	
B.J. − N.A.	+0.021	+0.18	57 "	
B.J. − 303	0.000	−0.51	49 "	(−2°)

The difference for 25 *Monocerotis* (R.A.) No. 96 of the List, has not been included.

With the above, it will be profitable to compare the mean differences between the observed and ephemeris places for 157 stars which are not in *B.J.*

MEAN DIFFERENCE: OBSERVED − EPHEMERIS.

	$\Delta\alpha$		$\Delta\delta$		
	s		″		
Obs. − *A.E.*	−0.028	sec δ	+0.02	67 stars	
Obs. − *C.T.*	+0.016	"	−0.24	86 "	
Obs. − *N.A.*	+0.008	"	+0.02	19 "	
Obs. − *N.A.* 1897	+0.025	"	−0.71	24 "	(−30°)
Obs. − 303	+0.013	"	−0.75	11 "	(−14°)

The following differences have been exclnded from the means:

A.E.	π *Hydrae*	(Decl.)	No. 166 of the List
C.T.	23 *Com. Ber.*	(R.A.)	No. 150
N.A.	ζ *Argus*	(Decl.)	No. 103
N.A. 1897	π 1 *Orionis*	(R.A. Decl.)	No. 57

These two comparisons may serve as an indication of the consistency of each ephemeris with its zone of equatorial stars; and of the extension, by this series of observations, of the *B.J.* system to the limits included.

The scheme of observing the ephemeris-stars, not in *B.J.*, was undertaken at Dr. HOLDEN's request.

OBSERVED PLACES. EPHEMERIS COMPARISON. OBS. — EPH.

Star	R.A. 1895.0	Decl. 1895.0	Obs.	*B. J.*		*A. E.*		*N. A.*		*C. T.*		303	
	h m s	° ′ ″		s	″	s	″	s	″	s	″	s	″
γ Pegasi	0 7 49.666	+14 35 58.87	12	−0.029	−0.30	−0.042	−0.29	+0.012	+0.07	+0.05	−0.3	. .	. .
ρ Androm.	12 50.416	+36 12 11.26	8	. .	. .	−0.121	+0.40	. .	. .	. .	. .	. .	. .
44 Piscium	20 1.189	+ 1 24 29.10	8	. .	. .	+0.014	−0.28	. .	. .	. .	. .	. .	. .
12 Ceti	24 40.812	− 4 32 15.41	12	+0.005	−0.14	+0.018	−0.62	+0.054	+0.01	+0.10	−1.2	+0.006	−0.71
13 Ceti	29 50.590	− 4 10 15.47	8	. .	. .	. .	. .	. .	. .	+0.13	−0.1	. .	. .
Piaz. 130	31 57.121	−25 20 42.92	8	. .	. .	. .	. .	. .	. .	+0.07	+1.2	. .	. .
21 Cassiopeae	38 42.846	+74 24 50.42	27	−0.003	0.00	+0.313	−0.39	. .	. .	. .	. .	. .	. .
Piaz. 189	42 52.462	+ 4 44 26.50	8	. .	. .	. .	. .	. .	. .	+0.38	+1.3	. .	. .
ν Androm.	44 1.297	+40 30 24.92	8	. .	. .	. .	. .	. .	. .	+0.20	−0.5	. .	. .
μ Androm.	50 55.407	+37 55 16.60	3	−0.129	−0.92	−0.009	−0.96	. .	. .	. .	. .	. .	. .
α Sculptoris	53 32.822	−29 55 30.76	8	. .	. .	. .	. .	. .	. .	+0.06	−0.6	. .	. .
43 H. Cephei	54 24.619	+85 41 37.23	16	−0.028	−0.22	+0.035	−0.26	. .	. .	. .	. .	. .	. .
ε Piscium	57 29.573	+ 7 19 29.20	11	+0.003	−0.30	−0.012	+0.07	+0.027	+0.39	−0.06	+0.5	. .	. .
μ Cassiopeae	1 1 16.985	+54 24 18.60	8	. .	. .	. .	. .	. .	. .	−0.03	−1.0	. .	. .
β Androm.	3 51.054	+35 3 49.94	3	−0.090	−0.38	−0.098	+0.42	−0.022	−0.17	+0.02	−0.1	. .	. .
f Piscium	12 22.907	+ 3 3 41.26	8	. .	. .	−0.004	+0.01	. .	. .	. .	. .	. .	. .
ϑ Ceti	18 46.486	− 8 43 31.46	12	−0.006	−0.59	+0.011	−0.62	+0.058	−0.47	+0.06	−1.0	+0.006	−0.99
α Urs. min.	20 29.389	+88 44 52.46	20	−0.416	−0.19	−0.685	−0.22	+0.768	−0.21	+0.87	−0.4	. .	. .
38 Cassiopeae	23 24.863	+69 43 26.68	8	. .	. .	+0.024	+0.06	. .	. .	. .	. .	. .	. .
40 Cassiopeae	30 7.407	+72 30 16.66	4	+0.004	−0.22	. .	. .	. .	. .	. .	. .	. .	. .
υ Androm.	30 37.953	+40 52 48.53	8	. .	. .	−0.098	−0.73	. .	. .	. .	. .	. .	. .
π Piscium	31 31.849	+11 36 15.02	8	. .	. .	−0.064	−1.24	. .	. .	. .	. .	. .	. .
ν Piscium	35 57.981	+ 4 57 21.97	8	+0.027	−0.26	−0.020	−0.27	+0.051	−0.27	+0.09	−0.3	+0.030	−0.26
ξ Piscium	48 7.128	+ 2 40 8.80	24	−0.015	+0.27	. .	. .	. .	. .	. .	. .	−0.001	−0.05
50 Cassiopeae	54 27.959	+71 54 46.24	19	−0.095	−0.46	+0.033	−0.84	. .	. .	. .	. .	. .	. .
ξ_1 Ceti	2 7 25.995	+ 8 21 14.23	8	. .	. .	−0.064	−0.14	. .	. .	. .	. .	. .	. .
ο Ceti*	14 2.516	− 3 27 16.66	11	+0.059	+0.39	. .	. .	. .	. .	−0.1	−0.8	+0.047	−0.71
ξ_2 Ceti	22 34.517	+ 7 59 21.31	24	−0.002	−0.13	−0.042	+0.14	+0.030	−0.03	+0.06	−0.2	. .	. .
36 H. Cass.	28 2.911	+72 21 31.11	23	−0.187	−0.22	. .	. .	. .	. .	. .	. .	. .	. .
Piaz. 123	30 19.347	+ 6 23 7.98	8	. .	. .	. .	. .	. .	. .	+0.12	+4.0	. .	. .
δ Ceti	34 5.976	− 0 7 28.53	12	−0.034	+0.64	−0.058	+0.67	. .	. .	. .	. .	−0.009	−0.32
β Fornacis	44 41.804	−32 50 50.17	8	. .	. .	. .	. .	. .	. .	0.00	−0.6	. .	. .
σ Arietis	45 41.673	+14 38 57.15	8	. .	. .	−0.012	+0.38	+0.055	+0.15	. .	. .	. .	. .
η Eridani	51 17.837	− 9 18 58.71	7	−0.003	−0.28	. .	. .	. .	. .	. .	. .	+0.010	−0.77
47 H. Cephei	52 7.669	+79 0 12.28	4	−0.261	−0.04	+0.161	+0.72	. .	. .	. .	. .	. .	. .
ε Arietis	53 12.381	+20 55 12.51	8	. .	. .	−0.055	−0.58	. .	. .	−0.04	−0.6	. .	. .
α Ceti	56 47.412	+ 3 40 39.70	4	+0.058	+0.27	+0.019	+0.36	+0.066	+0.29	+0.06	+0.7	+0.053	−0.28
τ 3 Eridani	57 45.764	−24 2 11.15	8	. .	. .	. .	. .	. .	. .	+0.07	−0.9	+0.012	−0.91
ρ Persei	58 26.787	+38 26 0.02	4	−0.001	+0.28	. .	. .	. .	. .	. .	. .	. .	. .
48 H. Cephei	3 6 59.910	+77 20 54.72	4	+0.227	−0.04	+0.123	+0.20	. .	. .	. .	. .	. .	. .
ζ Arietis	8 51.871	+20 39 18.41	8	. .	. .	−0.043	+0.08	. .	. .	. .	. .	. .	. .
ο Tauri	19 9.692	+ 8 39 32.96	20	−0.033	+0.06	. .	. .	+0.013	+0.29	. .	. .	. .	. .
ε Eridani	27 59.008	− 9 48 50.13	13	+0.047	+0.55	+0.029	−1.05	+0.068	+0.39	−0.04	+1.9	+0.027	−0.37
5 H. Cam.	39 16.405	+71 0 29.53	17	+0.092	−0.08	+0.068	−0.10	. .	. .	. .	. .	. .	. .
ξ Persei	52 9.041	+35 29 20.06	4	−0.009	+0.56	. .	. .	. .	. .	. .	. .	. .	. .
ν Tauri	57 34.184	+ 5 41 52.18	12	−0.038	+0.63	. .	. .	. .	. .	. .	. .	−0.015	−0.13
A_1 Tauri	58 29.170	+21 47 41.06	8	. .	. .	−0.068	+0.88	−0.009	−0.18	. .	. .	. .	. .
Gr. 750	4 3 39.151	+85 16 39.82	22	+0.002	+0.18	. .	. .	. .	. .	−0.44	−2.5	. .	. .
o_1 Eridani	6 44.345	− 7 6 41.88	8	−0.044	−0.17	−0.041	+0.10	+0.036	+0.57	. .	. .	−0.017	−0.20
o_2 Eridani	10 26.330	− 7 48 59.31	8	. .	. .	. .	. .	. .	. .	−0.15	−0.2	. .	. .
υ_4 Eridani	13 55.257	−34 3 18.12	8	. .	. .	. .	. .	+0.23	−1.0	. .	. .	. .	. .
d Eridani	20 5.567	−34 15 39.57	8	. .	. .	. .	. .	. .	. .	+0.02	+0.2	. .	. .
m Persei	26 1.548	+42 50 21.41	8	. .	. .	−0.054	+0.66	. .	. .	. .	. .	. .	. .
ν Eridani	31 4.331	− 3 34 2.65	8	+0.060	−0.26	. .	. .	. .	. .	. .	. .	+0.041	−0.41
Gr. 848	34 42.231	+75 44 57.75	27	−0.078	−0.40	. .	. .	. .	. .	. .	. .	. .	. .

* Observed magnitude 8½.

Observed Places. Ephemeris Comparison. Obs. — Eph.

Star	R.A. 1895.0	Decl. 1895.0	Obs.	B. J.		A. E.		N. A.		C. T.		303	
	h m s	° ′ ″		s	″	s	″	s	″	s	″	s	″
μ Eridani	4 40 15.107	− 3 26 50.71	3	+0.025	−0.22	. .	. .	+0.037	+0.15	. .	. .	+0.016	−0.57
π_1 Orionis	44 8.380	+ 6 46 40.04	8	. .	. .	. .	. .	+0.08	+1.6	−0.13	+0.3	. .	. .
i Tauri	45 13.839	+18 39 39.25	8	. .	. .	−0.036	+0.54	. .	. .	. .	. .	. .	. .
π_5 Eridani	48 46.859	+ 2 16 6.38	12	−0.047	+0.19	. .	. .	. .	. .	. .	. .	−0.030	−0.78
11 Orionis	58 34.092	+15 15 27.04	8	. .	. .	−0.010	−0.07	. .	. .	. .	. .	. .	. .
β Eridani	5 2 41.259	− 5 13 20.99	16	+0.013	−0.49	+0.001	−0.51	. .	. .	. .	. .	+0.015	−0.55
19 H. Cam.	5 15.127	+79 6 34.73	11	+0.101	+0.02	. .	. .	. .	. .	. .	. .	. .	. .
μ Leporis	8 12.876	−16 19 48.13	8	. .	. .	. .	. .	+0.02	+0.1	. .	. .	. .	. .
β Orionis	9 29.431	− 8 19 23.89	4	−0.029	−0.13	−0.053	−0.41	−0.027	−0.21	−0.04	−0.1	+0.009	−1.21
λ Aurigae	11 45.236	+40 0 19.34	8	. .	. .	. .	. .	. .	. .	0.00	−0.9	. .	. .
o Colomb.	13 41.863	−34 59 53.80	8	. .	. .	. .	. .	. .	. .	+0.04	−0.7	. .	. .
γ Orionis	19 29.939	+ 6 15 15.47	12	+0.039	+0.26	. .	. .	. .	. .	−0.07	−0.1	. .	. .
Gr. 966	25 40.950	+74 58 24.80	16	−0.160	+0.81	−0.620	−0.11	. .	. .	. .	. .	. .	. .
χ Aurigae	25 53.572	+32 6 50.38	8	. .	. .	−0.132	−1.38	. .	. .	. .	. .	. .	. .
Gr. 944	28 20.975	+85 8 36.13	16	. .	. .	−0.722	+0.62	. .	. .	. .	. .	. .	. .
ϵ Orionis	30 53.090	− 1 16 9.38	8	+0.024	−0.16	−0.015	−0.14	+0.028	−0.42	−0.02	+0.4	+0.006	−0.82
ζ Orion. (m)	35 27.633	− 1 59 54.55	8	. .	. .	. .	. .	. .	. .	−0.07	+0.4	. .	. .
α Colomb.	35 50.793	−34 7 49.40	8	. .	. .	−0.083	−0.10	−0.072	−0.73	−0.16	−0.7	. .	. .
κ Orionis	42 46.585	− 9 42 26.23	20	+0.048	−0.37	+0.020	−0.37	+0.040	+0.09	. .	. .	+0.045	−1.01
β Colomb.	47 15.499	−35 48 29.48	8	. .	. .	. .	. .	+0.04	−0.5	. .	. .	. .	. .
θ Aurigae	52 33.646	+37 12 17.87	9	−0.048	+0.18	−0.070	+0.33	. .	. .	+0.05	+1.7	. .	. .
γ Colomb.	53 48.853	−35 17 41.68	8	. .	. .	. .	. .	. .	. .	−0.03	−0.7	. .	. .
ν Orionis	6 1 34.587	+14 46 50.17	12	−0.018	−0.54	−0.094	−0.19	+0.028	−0.46	−0.04	−0.6	. .	. .
22 H. Cam.	7 16.530	+69 21 22.19	11	+0.011	+0.25	+0.241	+0.26	. .	. .	. .	. .	. .	. .
ζ Can. Maj.	16 16.936	−30 1 1.36	8	. .	. .	. .	. .	+0.095	−0.02	. .	. .	. .	. .
8 Monoc.	18 12.236	+ 4 38 45.39	16	−0.042	+0.35	. .	. .	. .	. .	. .	. .	. .	. .
ν Gemin.	22 43.680	+20 16 41.91	8	. .	. .	−0.025	+0.24	. .	. .	. .	. .	. .	. .
23 H. Cam.	28 18.530	+79 40 37.63	24	−0.182	+0.69	. .	. .	. .	. .	. .	. .	. .	. .
51 Aurigae	31 22.988	+39 28 58.61	5	+0.006	−0.24	. .	. .	. .	. .	. .	. .	. .	. .
S Monoc.	35 11.705	+ 9 59 33.24	20	−0.037	+0.08	. .	. .	. .	. .	. .	. .	. .	. .
18 Monoc.	42 23.148	+ 2 31 36.77	31	−0.009	+0.71	. .	. .	. .	. .	. .	. .	+0.003	−0.04
51 H. Cephei	51 15.505	+87 12 43.33	36	−0.640	+0.15	+1.060	+0.15	+0.121	+0.25	−1.3	+1.9	. .	. .
Piaz. 305	56 50.009	+29 30 46 31	8	. .	. .	. .	. .	. .	. .	−0.09	−3.6	. .	. .
22 Can. Maj.	57 32.179	−27 47 4.86	8	. .	. .	. .	. .	+0.07	−0.8	. .	. .	. .	. .
o_2 Can. Maj.	58 38.362	−23 40 48.67	8	. .	. .	. .	. .	−0.02	+0.1	. .	. .	. .	. .
25 Camelop.	7 8 58.548	+82 36 46.01	16	. .	. .	−0.825	−0.77	. .	. .	. .	. .	. .	. .
λ Gemin.	12 3.497	+16 43 45.96	20	−0.040	−0.58	. .	. .	. .	. .	. .	. .	. .	. .
π Puppis	13 26.061	−36 54 34.03	8	. .	. .	. .	. .	+0.01	−1.8	−0.03	−1.5	. .	. .
η Can. Maj.	19 56.472	−29 5 54.80	8	. .	. .	. .	. .	−0.09	−0.8	. .	. .	. .	. .
β Can. Min.	21 27.384	+ 8 30 2.42	8	−0.022	−0.13	−0.068	+0.36	+0.010	+0.31	−0.02	−0.3	. .	. .
25 Monoc.	32 3.450	− 3 52 36.48	16	+0.109	−0.05	. .	. .	. .	. .	. .	. .	−0.007	−0.70
ξ Navis	44 52.690	−24 35 48.02	8	. .	. .	. .	. .	−0.009	−0.51	−0.14	−0.7	. .	. .
9 Navis	46 54.561	−13 37 11.02	8	. .	. .	. .	. .	. .	. .	+0.02	−0.7	−0.002	−0.73
q Gemin.	47 4.280	+27 2 14.40	8	. .	. .	−0.041	−0.17	. .	. .	. .	. .	. .	. .
Gr. 1374	47 37.397	+74 11 51.89	16	+0.035	−0.48	0.000	−0.45	. .	. .	. .	. .	. .	. .
B.A.C. 2320	52 30.735	+88 56 47.43	16	. .	. .	. .	. .	. .	. .	+4.2	0.0	. .	. .
ω_1 Cancri	54 34.695	+25 40 48.07	8	. .	. .	−0.041	−0.36	. .	. .	. .	. .	. .	. .
ζ Argus	59 53.598	−39 42 28.16	8	. .	. .	. .	. .	−0.069	−2.05	. .	. .	. .	. .
3 Urs. Maj.	8 2 21.676	+68 46 58.04	8	. .	. .	−0.383	+0.39	. .	. .	. .	. .	. .	. .
ζ Cancri pr.	6 11.410	+17 57 50.70	8	. .	. .	−0.018	+1.64	. .	. .	. .	. .	. .	. .
Br. 1147	6 20.814	+76 4 36.77	31	−0.018	+0.08	. .	. .	. .	. .	. .	. .	. .	. .
β Cancri	10 49.234	+ 9 30 32.06	4	−0.027	−0.09	−0.038	+0.32	+0.008	+0.24	+0.06	0.0	. .	. .
Br. 1197	20 24.831	− 3 33 50.84	24	+0.022	−0.53	+0.009	−0.53	. .	. .	. .	. .	+0.001	−0.95
Gr. 1450	26 5.396	+38 22 34.44	4	+0.030	+1.14	. .	. .	. .	. .	. .	. .	. .	. .
δ Hydrae	32 5.844	+ 6 4 10.95	8	. .	. .	. .	. .	. .	. .	+0.05	+0.4	. .	. .

Observed Places.				Ephemeris Comparison. Obs. − Eph.									
Star	R.A. 1895.0	Decl. 1895.0	Obs.	*B. J.*		*A. E.*		*N. A.*		*C. T.*		303	
	h m s	° ′ ″		s	″	s	″	s	″	s	″	s	″
τ Hydrae	8 33 16.188	+ 3 42 35.53	8	. .	. .	−0.128	+0.15	. .	. .	. .	. .	. .	. .
γ Cancri	37 12.604	+21 50 45.17	8	. .	. .	−0.028	+0.11	−0.003	+0.09	. .	. .	. .	. .
α Pyxidis	39 22.429	−32 48 29.88	8	. .	. .	. .	. .	. .	. .	−0.10	+1.3	. .	. .
ε Hydrae	41 12.923	+ 6 48 14.22	7	−0.027	−0.07	−0.054	+0.42	−0.010	+0.30	−0.07	−0.1	. .	. .
α Cancri	52 14.693	+12 15 50.30	10	+0.016	−0.19	. .	. .	−0.015	+0.09	+0.03	0.0	. .	. .
B.A.C.3097	59 51.069	+38 52 18.00	8	. .	. .	. .	. .	. .	. .	−0.18	+1.1	. .	. .
κ Cancri	9 2 3.595	+11 5 26.00	8	. .	. .	−0.073	−0.37	+0.009	+0.10	−0.08	−0.6	. .	. .
ϑ Hydrae	8 54.097	+ 2 45 25.67	17	0.000	+0.24	−0.042	+0.40	. .	. .	. .	. .	+0.015	−0.47
1 H. Draco.	22 6.323	+81 47 24.17	35	+0.099	−0.41	−0.319	−0.37	. .	. .	. .	. .	. .	. .
ψ Argus	26 33.867	−40 0 26.67	8	. .	. .	. .	. .	. .	. .	−0.07	−0.5	. .	. .
o Leonis	35 32.810	+10 22 11.35	23	−0.021	−0.38	−0.006	−0.10	+0.013	+0.03	+0.07	−0.4	. .	. .
6 Sextantis	45 56.585	− 3 15 5.21	17	−0.017	−0.29	. .	. .	. .	. .	. .	. .	+0.019	−0.82
Gr. 1586	48 59.597	+73 22 42.52	25	−0.010	−0.75	. .	. .	. .	. .	. .	. .	. .	. .
π Leonis	54 39.892	+ 8 32 52.52	26	+0.005	+0.11	−0.007	+0.22	+0.020	+0.68	−0.04	+0.5	. .	. .
υ_2 Hydrae	10 0 0.690	−12 33 20.63	8	. .	. .	. .	. .	. .	. .	−0.08	−2.8	+0.009	−0.94
32 Urs. Maj.	10 24.194	+65 37 54.91	8	. .	. .	−0.039	+0.30	. .	. .	. .	. .	. .	. .
γ_1 Leonis	14 11.031	+20 22 21.44	8	. .	. .	−0.011	+0.14	+0.012	+0.67	+0.06	+0.2	. .	. .
B.A.C.3495	14 21.679	+84 47 7.18	16	. .	. .	. .	. .	. .	. .	+0.28	+2.1	. .	. .
9 H. Draco.	26 9.980	+76 15 13.76	48	+0.081	+0.25	−0.557	+0.67	. .	. .	. .	. .	. .	. .
37 Sextantis	40 37.672	+ 6 55 35.71	8	. .	. .	. .	. .	. .	. .	+0.01	+0.7	. .	. .
l Leonis	43 44.282	+11 6 2.59	20	−0.029	+0.09	−0.054	+0.05	+0.017	+0.01	+0.02	−0.5	. .	. .
α Leonis	54 39.484	−17 44 23.29	8	. .	. .	. .	. .	. .	. .	−0.01	−1.0	. .	. .
d Leonis	55 8.272	+ 4 10 52 40	8	. .	. .	. .	. .	+0.036	+0.29	. .	. .	. .	. .
χ Leonis	59 36.064	+ 7 54 13.25	21	+0.039	−0.02	. .	. .	+0.017	+0.46	+0.04	+0.7	. .	. .
p_3 Leonis	11 1 32.899	+ 2 31 31.50	8	. .	. .	+0.140	−0.08	. .	. .	. .	. .	. .	. .
σ Leonis	15 43.324	+ 6 36 17.26	17	+0.023	+0.24	. .	. .	. .	. .	. .	. .	. .	. .
83 Leonis	21 26.446	+ 3 35 7.05	8	. .	. .	. .	. .	. .	. .	+0.10	+0.6	. .	. .
τ Leonis	22 32.247	+ 3 26 4.19	8	. .	. .	+0.003	+0.24	+0.026	+0.29	. .	. .	. .	. .
λ Draconis	25 10.131	+69 54 38.09	11	−0.185	+0.06	+0.043	+0.15	−0.062	+0.26	−0.10	+1.3	. .	. .
υ Leonis	31 34.369	− 0 14 38.83	8	+0.041	−0.21	+0.010	+0.08	+0.059	−0.06	+0.07	+0.6	. .	. .
ζ Crateris	39 26.442	−17 46 1.66	8	. .	. .	. .	. .	. .	. .	+0.05	−0.9	+0.047	−0.99
β Virginis	45 13.525	+ 2 21 23.09	7	+0.015	+0.09	. .	. .	. .	. .	−0.01	+0.9	+0.009	−0.39
Gr. 1830	46 55.631	+38 28 19.11	8	. .	. .	. .	. .	. .	. .	−0.03	−2.1	. .	. .
π Virginis	55 29.528	+ 7 11 59.37	8	. .	. .	+0.024	+0.72	+0.041	0.00	+0.05	+0.6	. .	. .
o Virginis	59 51.624	+ 9 18 58.01	17	−0.015	−0.09	−0.003	−0.05	. .	. .	−0.05	+0.3	. .	. .
4 H. Draco.	12 7 16.632	−78 11 58.72	42	−0.119	−0.59	−0.570	−0.15	. .	. .	. .	. .	. .	. .
6 Urs. min.	14 21.980	+88 16 55.16	16	. .	. .	+0.665	−0.55	. .	. .	+2.0	+0.1	. .	. .
η Virginis	14 32.008	− 0 4 59.72	15	+0.008	+0.53	−0.035	+0.40	+0.037	+0.01	+0.03	+0.3	+0.008	+0.06
κ Draconis	29 0.038	+70 22 1.30	16	+0.077	+0.27	−0.138	+0.30	. .	. .	. .	. .	. .	. .
23 Com. Ber.	29 37.133	+23 12 26.96	8	. .	. .	. .	. .	. .	. .	−0.52	+0.5	. .	. .
f Virginis	31 22.841	− 5 15 11.46	8	. .	. .	. .	. .	. .	. .	−0.02	+1.8	. .	. .
γ Virg. (*m*)	36 20.349	− 0 52 24.85	4	−0.016	+0.08	−0.053	+0.60	. .	. .	. .	. .	. .	. .
31 Com. Ber.	46 35.012	+28 6 43.94	8	. .	. .	−0.163	+0.96	. .	. .	. .	. .	. .	. .
η Centauri	47 37.226	−39 36 29.28	8	. .	. .	. .	. .	. .	. .	+0.07	−1.0	. .	. .
32 H.Ceph.*seq*	48 20.948	+83 59 1.51	16	. .	. .	−0.507	+0.72	. .	. .	. .	. .	. .	. .
δ Virginis	50 18.820	+ 3 58 5.29	10	+0.017	+0.10	. .	. .	+0.017	+0.40	−0.03	+0.9	+0.020	0.00
ε Virginis	56 56.947	+11 31 24.57	19	−0.057	−0.08	−0.096	+0.02	−0.023	+0.13	. .	. .	. .	. .
ϑ Virginis	13 4 30.762	− 4 58 42.19	28	+0.027	+0.01	+0.006	+0.27	+0.015	+0.56	+0.01	+0.2	+0.016	−0.24
61 Virginis	12 54.691	−17 43 38.32	8	. .	. .	. .	. .	. .	. .	−0.06	−1.2	. .	. .
ι Centauri	14 41.611	−36 9 31.34	8	. .	. .	. .	. .	0.00	−1.9	. .	. .	. .	. .
Gr. 2001	23 27.334	+72 56 12.29	21	+0.005	−0.08	. .	. .	. .	. .	. .	. .	. .	. .
ζ Virginis	29 20.509	− 0 3 32.60	16	−0.008	−0.41	−0.033	−0.12	+0.008	−0.48	−0.03	−1.1	−0.002	−0.83
25 Can. Ven.	32 47.730	+36 49 44.46	8	. .	. .	. .	. .	. .	. .	−0.21	+0.4	. .	. .
m Virginis	36 6.008	− 8 10 23.53	8	. .	. .	+0.027	−0.55	. .	. .	+0.04	+0.3	−0.003	−0.87
τ Virginis	56 18.111	+ 2 3 9.82	10	+0.001	+0.83	. .	. .	+0.021	+0.02	+0.01	+0.8	−0.005	−0.36

Observed Places.				Ephemeris Comparison.						Obs. — Eph.			
Star	R.A. 1895.0	Decl. 1895.0	Obs.	*B.J.*		*A.E.*		*N.A.*		*C.T.*		303	
	h m s	° ′ ″		s	″	s	″	s	″	s	″	s	″
π Hydrae	14 0 23.146	−26 10 35.33	8	. .	*	+0.029	−3.18	+0.03	−0.4	. .	. .	. .	. .
ϑ Centauri	0 30.135	−35 51 12.22	8	. .	. .	. .	. .	+0.005	−1.20	−0.14	+3.7	. .	. .
4 Urs. min.	9 15.401	+78 2 27.28	31	−0.025	−0.22	−0.030	−0.25	. .	. .	. .	. .	. .	. .
ι Virginis	10 30.460	− 5 29 58.11	7	+0.042	−0.03	. .	. .	. .	. .	. .	. .	+0.020	−0.40
λ Virginis	13 25.624	−12 53 15.84	8	. .	. .	−0.035	+0.14	. .	. .	−0.04	−0.6	. .	. .
f Bootis	21 34.277	+19 41 56.58	8	. .	. .	. .	. .	−0.028	+0.13	. .	. .	. .	. .
q Virginis	22 47.475	− 1 45 25.68	4	−0.015	+0.33	. .	. .	. .	. .	. .	. .	−0.006	−0.29
5 Urs. min.	27 44.746	+76 9 46.29	16	. .	. .	−0.120	+0.50	. .	. .	. .	. .	. .	. .
μ Virginis	37 31.549	− 5 12 5.60	15	+0.012	+0.18	. .	. .	. .	. .	. .	. .	+0.005	−0.25
ϵ_2 Bootis	40 24.012	+27 31 1.26	8	. .	. .	−0.137	+0.49	−0.042	+0.38	−0.02	0.0	. .	. .
β Urs. min.	51 0.567	+74 35 4.19	7	−0.126	−0.16	−0.119	−0.26	−0.101	−0.51	−0.04	+0.7	. .	. .
ξ_2 Librae	51 4.172	−10 59 8.89	8	. .	. .	. .	. .	. .	. .	+0.02	−0.1	+0.006	−0.57
Piaz. 224	51 15.827	+14 52 14.50	8	−0.059	−0.70	. .	. .	. .	. .	. .	. .	. .	. .
Piaz. 212	51 20.030	−20 56 29.97	8	. .	. .	. .	. .	. .	. .	+0.24	−2.2	. .	. .
Gr. 2283	15 11 3.840	+87 38 11.51	16	. .	. .	. .	. .	. .	. .	−2.5	−1.8	. .	. .
β Librae	11 21.331	− 8 59 43.23	19	−0.018	+0.17	−0.034	+0.28	+0.010	+0.20	−0.01	−0.5	−0.008	−0.39
η Coronae	18 51.974	+30 40 1.42	8	. .	. .	. .	. .	. .	. .	−0.01	+0.1	. .	. .
γ Urs. min.	20 53.593	+72 12 27.21	12	−0.320	−0.38	−0.161	−0.19	. .	. .	−0.78	−1.6	. .	. .
ζ_1 Librae	22 20.030	−16 21 0.98	8	. .	. .	. .	. .	. .	. .	−0.03	0.0	+0.020	−0.39
κ Librae	35 53.767	−19 20 18.07	8	. .	. .	. .	. .	. .	. .	+0.04	−0.9	. .	. .
α Serpentis	39 5.720	+ 6 45 22.17	16	−0.001	+0.37	−0.026	+0.65	+0.035	+0.31	+0.03	−0.3	. .	. .
ε Serpentis	45 34.867	+ 4 47 38.18	16	+0.017	+0.39	−0.038	−0.11	+0.030	+0.13	. .	. .	+0.004	+0.10
λ Librae	47 14.283	−19 51 10.74	8	. .	. .	. .	. .	. .	. .	+0.02	−0.9	. .	. .
ζ Urs. min.	47 48.407	+78 7 2.56	22	+0.020	−0.09	−0.308	−0.02	+0.049	−0.17	−0.81	−0.5	. .	. .
π Scorpii	52 29.953	−25 48 41.73	8	. .	. .	. .	. .	+0.09	−0.2	. .	. .	. .	. .
49 Librae	54 25.994	−16 13 25.99	8	. .	. .	. .	. .	. .	. .	−0.07	−0.9	. .	. .
ν_2 Scorpii	16 5 53.535	−19 11 15.53	8	. .	. .	. .	. .	. .	. .	−0.01	−0.7	. .	. .
Gr. 2320	6 2.099	+68 5 12.20	8	. .	. .	+0.211	−0.45	. .	. .	. .	. .	. .	. .
δ Ophiuchi	8 50.507	− 3 25 25.80	5	−0.015	−0.11	−0.055	−0.16	+0.017	−0.07	+0.02	−1.4	−0.015	−0.62
σ_1 Cor. Bor.†	10 44.571	+34 7 25.21	7	. .	. .	−0.05	−2.8	. .	. .	+0.14	+0.5	. .	. .
19 Urs. min.	13 48.987	+76 8 30.77	12	+0.069	+0.48	. .	. .	. .	. .	. .	. .	. .	. .
σ Scorpii	14 48.331	−25 20 26.29	8	. .	. .	. .	. .	+0.07	−1.0	+0.01	−1.6	. .	. .
A Draconis	28 11.202	+68 59 43.04	8	+0.056	−0.16	−0.305	+0.70	. .	. .	. .	. .	. .	. .
τ Scorpii	29 20.720	−27 59 52.66	8	. .	. .	. .	. .	+0.07	−0.2	+0.01	−1.3	. .	. .
ζ Ophiuchi	31 22.574	−10 21 15.39	20	+0.010	−0.08	−0.025	−0.11	+0.038	−0.04	. .	. .	+0.021	−0.70
η Herculis	39 17.752	+39 7 19.23	12	−0.038	−0.23	+0.018	+0.03	. .	. .	. .	. .	. .	. .
ε Scorpii	43 21.721	−34 6 8.89	8	. .	. .	. .	. .	+0.01	−1.2	+0.02	+3.0	. .	. .
κ Ophiuchi	52 41.852	+ 9 32 18.22	23	+0.010	−0.40	−0.041	−0.23	+0.028	+0.43	+0.07	−1.4	. .	. .
ε Urs. min.	56 43.594	+82 12 35.20	28	−0.195	+0.09	−0.406	+0.30	+0.023	+0.42	−0.52	0.0	. .	. .
d Herculis	57 43.755	+33 43 13.26	8	. .	. .	+0.014	−0.27	. .	. .	. .	. .	. .	. .
A_1 Ophiuchi	17 8 53.411	−26 26 54.28	8	. .	. .	. .	. .	. .	. .	−0.01	+0.9	. .	. .
α Herculis	9 51.544	+14 30 36.76	12	+0.009	+0.67	−0.029	+0.29	+0.019	+0.53	+0.03	−0.4	. .	. .
π Herculis	11 23.373	+36 55 39.10	12	−0.002	+0.20	−0.046	−0.07	. .	. .	+0.05	−1.5	. .	. .
ω Herculis	16 43.809	+32 36 10.72	8	. .	. .	. .	. .	. .	. .	+0.03	−0.7	. .	. .
b Ophiuchi	19 57.435	−24 4 42.66	8	. .	. .	−0.002	−0.22	. .	. .	. .	. .	. .	. .
d Ophiuchi	20 38.964	−29 46 18.00	8	. .	. .	. .	. .	. .	. .	+0.17	+1.7	. .	. .
σ Ophiuchi	21 18.259	+ 4 13 54.42	8	. .	. .	. .	. .	+0.032	+0.13	. .	. .	. .	. .
υ Scorpii	23 37.504	−37 12 42.38	8	. .	. .	. .	. .	+0.08	−0.9	. .	. .	. .	. .
λ Scorpii	26 28.663	−37 1 36.85	8	. .	. .	. .	. .	−0.01	−0.6	. .	. .	. .	. .
α Ophiuchi	30 3.567	+12 38 11.90	16	−0.022	+0.10	−0.047	+0.25	−0.005	+0.49	+0.04	+0.8	. .	. .
κ Scorpii	35 13.397	−38 58 32.44	8	. .	. .	. .	. .	−0.07	−1.6	+0.01	−3.0	. .	. .
β Ophiuchi	38 17.092	+ 4 36 41.01	28	+0.003	+0.08	. .	. .	+0.020	+0.62	+0.10	−0.8	−0.004	−0.04
ψ Drac. *aus.*	43 48.245	+72 12 1.17	24	+0.011	+0.04	−0.040	+0.39	. .	. .	. .	. .	. .	. .
ϑ Herculis	52 39.105	+37 15 52.14	4	−0.051	+0.13	+0.020	−0.15	. .	. .	. .	. .	. .	. .
ν Ophiuchi	53 14.738	− 9 45 37.62	33	+0.010	−0.83	. .	. .	. .	. .	0.00	−0.4	+0.015	−0.70

* Proper motion: *A.E.* 0″.00; *N.A.* 1897, —0″.17. | † Obs. S. preceding star. *C.T.* N. fol. *A.E.* mean. $\Delta\alpha$ and $\Delta\delta$ from direct measure.

Observed Places.				Ephemeris Comparison. Obs. − Eph.									
Star	R.A. 1895.0	Decl. 1895.0	Obs.	*B. J.*		*A. E.*		*N. A.*		*C. T.*		393	
	h m s	° ′ ″		s	″	s	″	s	″	s	″	s	″
35 Draconis	17 54 8.877	+76 58 35.45	11	−0.106	+0.09	. .	. .	. .	. .	. .	. .	. .	. .
γ_2 Sagit.	*59 3.725	−30 25 30.10	8	−0.047	+1.04	−0.019	+0.57	+0.04	−0.4	−0.04	+0.2	. .	. .
p_1 Ophiuchi	18 0 8.980	+ 2 31 26.71	8	. .	. .	. .	. .	. .	. .	+0.28	−0.7	. .	. .
72 Ophiuchi	2 22.256	+ 9 32 56.82	8	−0.008	+0.18	. .	. .	+0.002	+0.70	. .	. .	. .	. .
δ Urs. min.	6 9.891	+86 36 45.19	29	−0.345	+0.21	−0.387	+0.12	−0.084	+0.40	−0.96	+0.4	. .	. .
η Sagit.	10 31.347	−36 47 34.96	8	. .	. .	. .	. .	0.00	−2.2	. .	. .	. .	. .
δ Sagit.	14 16.304	−29 52 20.66	8	. .	. .	. .	. .	+0.04	0.0	+0.11	+0.8	. .	. .
η Serpentis	15 52.599	− 2 55 33.25	8	+0.059	−0.48	+0.011	−1.11	+0.066	+0.01	+0.03	−1.5	+0.036	−0.71
ε Sagit.	17 12.125	−34 26 1.96	8	. .	. .	. .	. .	−0.035	+0.17	0.00	+3.9	. .	. .
λ Sagit.	21 29.426	−25 28 46.04	8	. .	. .	−0.005	+0.99	+0.024	+0.39	. .	. .	. .	. .
χ Draconis	22 56.919	+72 41 14.28	4	−0.012	+0.31	−0.017	+0.65	. .	. .	. .	. .	. .	. .
I Aquilae	29 29.568	− 8 19 2.20	8	. .	. .	−0.027	+0.48	. .	. .	. .	. .	. .	. .
α Lyrae	33 22.937	+38 41 9.23	4	−0.071	−0.66	−0.085	−0.01	−0.025	−0.34	+0.01	−0.6	. .	. .
q Sagit.	39 5.785	−27 5 53.92	8	. .	. .	. .	. .	+0.05	+0.6	+0.05	+0.3	. .	. .
ε Lyrae pr.	40 51.615	+39 33 36.88	8	−0.043	−0.46	. .	. .	. .	. .	. .	. .	. .	. .
β Lyrae	46 12.178	+33 14 27.11	12	−0.015	−0.38	−0.030	+0.57	+0.020	−0.30	+0.10	+0.3	. .	. .
50 Draconis	49 45.635	+75 18 36.38	16	. .	. .	+0.126	+0.28	. .	. .	. .	. .	. .	. .
ξ_2 Sagit.	51 27.938	−21 14 40.10	8	. .	. .	. .	. .	+0.02	−0.8	. .	. .	. .	. .
γ Lyrae	55 0.943	+32 32 44.46	4	+0.028	+0.15	−0.024	+0.16	. .	. .	+0.04	−0.5	. .	. .
ζ Sagit.	55 55.890	−30 1 47.61	8	. .	. .	. .	. .	+0.08	−0.5	+0.13	+1.2	. .	. .
τ Sagit.	19 0 23.089	−27 49 25.12	8	. .	. .	. .	. .	+0.04	−0.3	. .	. .	. .	. .
λ Aquilae	0 40.584	− 5 2 23.46	31	+0.024	−0.01	. .	. .	. .	. .	+0.03	−1.2	+0.003	−0.81
ι Lyrae	3 33.257	+35 56 8.28	4	−0.060	−0.13	−0.074	−0.13	. .	. .	. .	. .	. .	. .
d Sagit.	11 29.500	−19 8 22.78	8	. .	. .	+0.014	−0.44	. .	. .	. .	. .	+0.020	−1.00
ϑ Lyrae	12 43.373	+37 56 48.11	4	+0.040	+0.15	+0.028	+0.14	. .	. .	. .	. .	. .	. .
ω Aquilae	12 53.242	+11 24 22.33	22	−0.022	+0.03	. .	. .	+0.009	+0.46	+0.06	−0.7	. .	. .
τ Draconis	17 34.256	+73 9 37.49	14	−0.093	−0.40	−0.171	−0.22	. .	. .	. .	. .	. .	. .
b Aquilae	19 57.763	+11 43 11.36	8	. .	. .	. .	. .	. .	. .	−0.16	−3.0	. .	. .
δ Aquilae	20 12.227	+ 2 54 20.16	29	−0.011	+0.31	−0.027	+0.15	+0.025	+0.04	+0.07	−0.6	−0.006	−0.47
λ Urs. min.	28 4.935	+88 58 39.48	35	−0.756	+0.48	−1.50	+0.17	−0.482	+0.13	−1.1	−0.4	. .	. .
κ Aquilae	31 14.561	− 7 15 38.83	8	. .	. .	+0.013	−0.39	. .	. .	+0.01	−0.9	+0.005	−0.64
β Sagit.	36 19.959	+17 13 58.44	8	. .	. .	−0.034	+0.61	. .	. .	. .	. .	. .	. .
15 Cygni	40 29.362	+37 6 2.54	4	−0.057	−0.11	. .	. .	. .	. .	. .	. .	. .	. .
γ Aquilae	41 16.026	+10 21 26.97	31	−0.018	−0.01	−0.045	+0.08	+0.001	+0.53	+0.04	−0.8	. .	. .
β Aquilae	50 9.294	+ 6 8 41.00	8	−0.007	+0.35	−0.043	+0.69	+0.036	+0.14	+0.03	0.0	. .	. .
c Sagit.	56 12.156	−28 0 5.79	11	. .	. .	+0.014	−0.64	. .	. .	+0.11	−0.4	. .	. .
τ Aquilae	59 0.599	+ 6 58 54.68	11	. .	. .	−0.096	+0.67	. .	. .	. .	. .	. .	. .
ϑ Aquilae	20 5 53.234	− 1 7 58.21	13	+0.045	+0.02	+0.028	+0.16	+0.051	−0.38	+0.07	−0.6	+0.027	−0.29
κ Cephei	12 25.291	+77 23 42.36	33	+0.016	+0.33	−0.025	−0.16	. .	. .	. .	. .	. .	. .
γ Cygni	18 27.571	+39 55 13.79	12	−0.047	−0.82	−0.135	−0.20	. .	. .	+0.06	−1.2	. .	. .
π Capric.	21 18.675	−18 33 21.30	9	. .	. .	−0.033	−0.40	. .	. .	. .	. .	. .	. .
ε Delphini	28 11.785	+10 56 47.43	19	+0.002	+0.30	−0.042	−0.27	+0.025	+0.84	. .	. .	. .	. .
Gr. 3241	30 27.663	+72 10 33.19	17	. .	. .	+0.112	−0.25	. .	.	. .	. .	. .	. .
ψ Capric.	39 52.743	−25 38 53.37	9	. .	. .	−0.004	−0.34	. .	. .	+0.05	0.0	. .	. .
ε Cygni	41 57.740	+33 34 37.07	12	−0.025	−0.04	−0.038	+0.28	. .	. .	+0.05	−0.1	. .	. .
ε Aquarii	41 59.534	− 9 52 48.26	13	+0.023	+0.18	. .	. .	+0.027	+0.11	. .	. .	+0.021	−0.50
3 Aquarii	42 11.841	− 5 24 43.47	9	. .	. .	. .	. .	. .	. .	+0.10	−0.7	. .	. .
μ Aquarii	46 59.444	− 9 22 37.63	9	. .	. .	−0.009	+0.53	. .	. .	+0.05	−0.4	. .	. .
76 Draconis	50 10.796	+82 8 31.93	24	−0.035	+0.05	. .	. .	. .	. .	. .	. .	. .	. .
ν Cygni	53 15.438	+40 45 46.04	8	−0.079	−0.73	−0.068	−0.45	. .	. .	. .	. .	. .	. .
ζ Micros.	56 15.428	−39 2 29.47	8	. .	. .	. .	. .	. .	. .	+0.09	−2.1	. .	. .
ϑ Capric.	21 0 2.722	−17 39 0.17	9	. .	. .	. .	. .	+0.061	+0.21	. .	. .	. .	. .
61 Cygni pr.	2 11.450	+38 13 58.48	4	+0.185	−0.17	+0.071	−0.35	+0.134	+0.15	+0.37	+0.1	. .	. .
Br. 2777	7 35.860	+77 42 1.71	11	+0.055	+0.01	. .	. .	. .	. .	. :	. .	. .	. .
α Equulei	10 34.500	+ 4 48 49.75	13	+0.019	+0.03	. .	. .	. .	. .	. .	. .	+0.016	−0.38

* Error *C.T.* 1 min. R.A.

Observed Places.				Ephemeris Comparison. Obs. — Eph.									
Star	R.A. 1895.0	Decl. 1895.0	Obs.	B. J.		A. E.		N. A.		C. T.		303	
	h m s	° ′ ″		s	″	s	″	s	″	s	″	s	″
4 Pis. Aus.	21 11 34.313	−32 36 40.73	8	. .	. .	. .	. .	. .	. .	+0.11	−0.3	. .	. .
σ Cygni	13 17.455	+38 57 16.40	9	. .	. .	. .	. .	. .	. .	+0.06	+0.2	. .	. .
Gr. 3548	20 31.975	+86 36 7.72	17	. .	. .	. .	. .	. .	. .	−0.66	−0.3	. .	. .
β Cephei	27 18.300	+70 5 59.56	11	−0.055	+0.68	+0.030	+0.69	+0.077	+0.91	+0.07	+1.8	. .	. .
ξ Aquarii	32 9.762	− 8 19 30.18	9	. .	. .	−0.018	0.00	. .	. .	. .	. .	. .	. .
ε Pegasi	39 1.702	+ 9 23 37.04	35	−0.030	−0.14	−0.057	−0.05	+0.002	+0.33	−0.03	−0.8	. .	. .
γ Gruis	47 34.304	−37 51 31.83	8	. .	. .	. .	. .	+0.09	−0.5	+0.07	−1.1	. .	. .
μ Capric.	47 34.326	−14 2 45.41	9	. .	. .	+0.020	+0.23	. .	. .	. .	. .	. .	. .
79 Draconis	51 33.222	+73 12 20.14	17	. .	. .	−0.053	+0.01	. .	. .	. .	. .	. .	. .
20 Pegasi	55 58.385	+12 37 1.23	16	+0.058	+0.48	. .	. .	. .	. .	. .	. .	. .	. .
24 Cephei	22 7 47.329	+71 49 26.09	47	+0.060	−0.26	. .	. .	. .	. .	. .	. .	. .	. .
ϑ Aquarii	11 17.586	− 8 18 22.07	7	+0.007	−0.13	−0.010	−0.15	+0.031	+0.15	+0.05	−0.6	+0.019	−0.61
γ Aquarii	16 13.967	− 1 54 59.07	21	+0.006	+0.02	+0.002	+0.04	+0.015	−0.04	−0.01	−0.5	0.000	−0.31
π Aquarii	19 54.873	+ 0 50 40.42	8	. .	. .	−0.028	−0.17	. .	. .	. .	. .	. .	. .
σ Aquarii	25 5.481	−11 12 55.09	8	. .	. .	+0.075	−0.41	. .	. .	. .	. .	+0.036	−0.48
226 Cephei	30 25.620	+75 41 7.26	16	. .	. .	−0.298	+0.25	. .	. .	. .	. .	. .	. .
γ Aquarii	47 8.210	− 8 8 18.10	34	+0.039	+0.15	−0.024	−0.40	+0.037	+0.10	+0.17	−0.7	+0.033	−0.65
α Pegasi	59 31.778	+14 38 24.88	37	−0.013	−0.41	−0.043	−0.08	−0.006	+0.08	+0.04	−0.9	. .	. .
π Cephei	23 4 33.442	+74 49 11.33	25	−0.031	−0.06	. .	. .	. .	. .	. .	. .	. .	. .
ϙ Aquarii	8 53.063	− 6 36 54.37	8	. .	. .	−0.039	−0.49	. .	. .	. .	. .	. .	. .
γ Piscium	11 43.300	+ 2 42 30.53	9	+0.018	−0.18	. .	. .	+0.020	+0.02	+0.06	+0.2	+0.024	−0.52
γ Sculptoris	13 9.294	−33 6 15.17	8	. .	. .	. .	. .	. .	. .	+0.08	−1.5	. .	. .
ο Cephei	14 18.706	+67 32 13.15	8	. .	. .	−0.187	−0.44	. .	. .	. .	. .	. .	. .
κ Piscium	21 32.990	+ 0 40 50.82	7	+0.038	+0.29	. .	. .	+0.037	+0.48	0.00	+0.6	+0.008	−0.24
ϑ Piscium	22 38.487	+ 5 48 8.09	8	. .	. .	−0.001	+0.59	. .	. .	. .	. .	. .	. .
β Sculptoris	27 20.471	−38 23 57.07	8	. .	. .	. .	. .	. .	. .	+0.06	−0.7	. .	. .
39 H. Cephei	27 49.042	+86 43 41.93	16	. .	. .	. .	. .	. .	. .	−0.27	+1.8	. .	. .
ι Piscium	34 32.945	+ 5 3 25.78	12	+0.003	+0.34	−0.031	−0.04	+0.035	+0.25	0.00	0.0	+0.011	−0.09
γ Cephei	35 2.276	+77 2 46.75	15	+0.009	+0.59	+0.223	+0.40	+0.061	+0.12	−0.04	0.0	. .	. .
i_1 Aquarii	38 45.354	−18 51 35.08	8	. .	. .	−0.030	−0.43	. .	. .	. .	. .	. .	. .
Gr. 4163	49 43.260	+73 49 33.82	16	. .	. .	−0.289	+0.34	. .	. .	. .	. .	. .	. .
ω Piscium	53 55.128	+ 6 16 55.06	24	+0.006	−0.15	−0.036	−0.02	+0.034	+0.21	+0.06	0.0	. .	. .
30 Piscium	56 34.514	− 6 35 51.75	8	. .	. .	. .	. .	. .	. .	+0.09	−0.2	. .	. .
2 Ceti	58 21.643	−17 55 14.54	8	. .	. .	. .	. .	. .	. .	+0.06	−1.5	−0.005	−0.76
33 Piscium	59 57.634	− 6 17 42.16	8	. .	. .	−0.032	−0.75	. .	. .	. .	. .	. .	. .

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN., WITH A 4½-INCH REFRACTOR,

BY A. W. QUIMBY.

(Continued from page 184.)

1897	Time	New Grs.	Total		Fac. Grs.	Def.	1897	Time	New Grs.	Total		Fac. Grs.	Def.	1897	Time	New Grs.	Total		Fac. Grs.	Def.
			Grs.	Spots						Grs.	Spots						Grs.	Spots		
Apr. 23	8	–	1	1	2	fair	May 5	8	–	3	16	–	poor	May 16	8	–	–	–	2	fair
24	5	1	2	2	2	fair	6	7	–	2	35	2	fair	17	7	–	–	–	1	fair
25	7	–	2	2	2	fair	7	9	1	2	32	2	good	18	7	–	–	–	2	fair
26	7	–	–	–	3	poor	8	7	–	3	17	2	poor	19	5	1	1	3	2	poor
27	5	–	1	1	3	fair	9	8	–	3	11	2	poor	20	8	–	1	7	2	fair
28	4	2	3	6	4	poor	10	5	–	3	5	1	fair	21	11	1	2	15	1	poor
29	9	–	3	11	3	fair	11	7	–	2	3	2	fair	22	7	–	2	16	–	fair
30	8	–	2	6	2	poor	12	3	–	1	1	1	poor	23	7	–	2	18	–	fair
May 1	8	1	2	7	2	poor	13	6	–	–	–	–	poor	24	1	–	1	6	–	poor
2	4	2	4	26	3	fair	14	11	–	1	1	2	fair	25	7	2	4	21	1	good
3	8	–	3	37	2	fair	15	9	–	1	2	2	good	26	7	–	2	6	1	fair
4	7	–	4	32	2	fair														

NOTE. — The foregoing observations, from 1897 April 23 to May 26, complete the series printed in *A.J.* 407. The page of manuscript containing this portion of the series was lost by an unexplained mishap, and the Rev. Mr. QUIMBY has now supplied the omission. — ED.

OBSERVATIONS OF D'ARREST'S COMET = a 1897,

MADE AT THE LICK OBSERVATORY OF THE UNIVERSITY OF CALIFORNIA, WITH THE 12-INCH EQUATORIAL,

BY C. D. PERRINE.

1897 Mt. Hamilton M.T.	*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
June 28 15h 19m 25s	1	3	+0m 18s.41	. . .	2h 1m 24s.55	. . .	n9.624	. .
15 27 39	1	2	. . .	+0′ 29″.0	. . .	+6° 13′ 31″.7	. .	0.694
29 14 55 46	3	11 , 8	+0 48.20	+2 54.9	2 4 15.36	+6 16 7.7	n9.641	0.701

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	2h 1m 4s.29	+1s.85	+6° 12′ 17″.8	+14″.9	Micrometer-comparison with *2
2	2 0 30.59	+1.85	+6 11 5.8	+14.9	⅓ (W.B. 1033+2 Paris 2618)
3	2 3 25.29	+1.87	+6 12 57.7	+15.1	Paris 2662

Observations of June 28 made in dawn when comet was very faint.

Comet is about 2′ in diameter, and has a not very well marked central condensation, but no nucleus. Comet seems to be slightly extended north-preceding. It is just discernible in the 3½-inch finder of 12-inch telescope.

Mt. Hamilton, 1897 *July* 1.

ELLIPTIC ELEMENTS OF COMET g 1896.

BY ANNE S. YOUNG.

(Communicated by W. W. PAYNE, Director).

The following elements were computed by Miss ANNE S. YOUNG, student in astronomy at Goodsell Observatory, from a normal place Dec. 11, an observation at Northfield Jan. 5, and one at Charlottesville, Jan. 30.

Epoch 1896 Dec. 11.5

$$M = 2^\circ\ 32'\ 31''.9$$

$$\left.\begin{aligned} \Omega &= 246^\circ\ 32'\ 58''.7 \\ \omega &= 163\ 56\ 25.8 \\ \pi &= 50\ 29\ 24.5 \\ i &= 13\ 41\ 26.0 \end{aligned}\right\}\text{Mean Equinox 1897.0}$$

$$\begin{aligned} \sin\varphi &= 9.833766 \\ \log a &= 0.543092 \\ \log\mu &= 2.735369 \end{aligned}$$

ON ANDERSON'S NEW VARIABLE IN ANDROMEDA,*

$\alpha = 0^h\ 42^m\ 14^s$, $\delta = +34^\circ\ 53'$ (1855),

BY PAUL S. YENDELL.

The variability of this star was announced by ANDERSON, *A.N.*, Vol. 142, p. 159.

I have observations of it on two dates, which appear to confirm its variability. On 1897 Jan. 30, I found the star at $9^M.5$, by comparison with the stars DM. 35°221, $9^M.3$, and 34°141, $9^M.5$. On 1897 June 26 I found it to be invisible in my telescope, and made sure that nothing so bright as 10^M existed in its place.

Dorchester, Mass., 1897 *July* 12.

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* 267 *V Andromedae* : See *A.J.* 395, footnote to p. 87. — ED.

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ELLIPTIC ELEMENTS OF COMET g 1896, BY MISS ANNE S. YOUNG.
ON ANDERSON'S NEW VARIABLE IN ANDROMEDA, BY MR. PAUL S. YENDELL.

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THE

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SECULAR PERTURBATIONS OF *VENUS* BY THE ACTION OF *MERCURY*.

By ERIC DOOLITTLE.

In the following computation the orbit of *Venus* was at first divided into twelve parts with reference to the eccentric anomaly. The eccentricity of the orbit of *Mercury* is, however, so great that the sums of the functions corresponding respectively to the odd and even points of division afford practically no test of the correctness of the computation. The disagreements, for example of h, $\log P$ and R_0 were respectively 5725, 3374 and 32726 in units of the seventh decimal, while the sums used in obtaining the differential coefficients differed by so much as 52,694. A partial computation showed also that a division into sixteen parts was not sufficient to remove the discrepancy, which increases as the computation proceeds. A division into twenty-four parts is required if the sums of the functions are to furnish a test of the work.

The computation was carried through twice from the beginning; in the duplication, addition-tables of logarithms were used, and the form of the equations was changed when possible. The usual test-equations were also applied.

The elements are from Dr. G. W. Hill's "*New Theory of Jupiter and Saturn*," p. 192. Epoch 1850.0 G.M.T.

Venus

$e = 0.00684311$
$\pi = 129^\circ\ 27'\ 42''.83$
$i = 3\ 23\ 35.01$
$\Omega = 75\ 19\ 53.08$
$\log a = 9.8593378$
$m = \frac{1}{408134}$

Mercury

$e' = 0.20560476$
$\pi' = 75^\circ\ 7'\ 13''.62$
$i' = 7\ 0\ 7.71$
$\Omega' = 46\ 33\ 8.63$
$\log a' = 9.5878217$
$m' = \frac{1}{7500000}$

The results of the computation are as follows:

$I = 4^\circ\ 20'\ 42''.98$
$II = 104\ 54\ 1.25$
$II' = 50\ 39\ 31.36$
$K = 54\ 19\ 21.07$
$K' = 54\ 9\ 38.84$

$\log k = 9.9992531$
$\log k' = 9.9994984$
$\log c = 7.8017096$
$c = 0.0063344603$

E	log r	v	A	log B	ϵ	log q	h
°		° ′ ″			° ′ ″		
0	9.8563557	0 0 0.00	0.73249627	9.4664873	48 49 44.52	6.4879840	0.58840054
15	9.8564576	15 6 6.54	0.70628935	9.4546248	63 12 32.29	6.6123278	0.56402284
30	9.8567564	30 11 47.87	0.67778527	9.4421170	78 2 28.54	6.6668852	0.53673295
45	9.8572313	45 16 40.52	0.64892716	9.4299816	93 19 9.02	6.6602144	0.50812387
60	9.8578493	60 20 24.50	0.62168527	9.4191209	108 59 33.93	6.5913294	0.48000449
75	9.8585680	75 22 44.64	0.59791027	9.4101994	124 58 50.96	6.4490410	0.45436878
90	9.8593378	90 23 31.50	0.57923027	9.4035883	141 11 26.02	6.2030502	0.43333042
105	9.8601064	105 22 42.20	0.56691636	9.3994119	157 32 12.47	5.7648464	0.41895978
120	9.8608213	120 20 20.31	0.56180731	9.3976644	173 57 6.86	4.6424166	0.41292353
135	9.8614342	135 16 35.65	0.56425026	9.3983358	190 22 57.15	5.1099844	0.41598961
150	9.8619040	150 11 43.65	0.57407787	9.4014692	206 46 34.88	5.9120554	0.42773114
165	9.8621990	165 6 4.12	0.59061890	9.4071207	223 4 3.01	6.2846138	0.44670373
180	9.8622996	180 0 0.00	0.61274521	9.4152419	239 10 13.61	6.4998718	0.47092914
195	9.8621990	194 53 55.88	0.63894853	9.4255469	254 59 14.26	6.6226394	0.49830819
210	9.8619040	209 48 16.35	0.66744400	9.4374435	270 25 35.44	6.6765726	0.52683118
225	9.8614342	224 43 24.35	0.69628968	9.4500636	285 25 27.03	6.6699758	0.55465379
240	9.8608213	239 39 39.69	0.72352217	9.4623818	299 57 32.77	6.6018920	0.58013161
255	9.8601064	254 37 17.80	0.74728586	9.4733647	314 3 25.56	6.4614704	0.60184004
270	9.8593378	269 36 28.50	0.76596211	9.4821018	327 47 8.52	6.2195100	0.61860745
285	9.8585680	284 37 15.36	0.77827946	9.4878921	341 14 38.63	5.7917592	0.62954598
300	9.8578493	299 39 35.50	0.78339732	9.4902878	354 33 6.28	4.7372454	0.63407808
315	9.8572313	314 43 19.48	0.78096661	9.4733647	7 50 18.20	5.0494328	0.63196045
330	9.8567564	329 48 12.13	0.77115125	9.4844658	21 14 4.66	5.8885094	0.62329194
345	9.8564576	344 53 53.46	0.75461912	9.4878921	34 51 47.37	6.2693532	0.60851491
Σ_1	8.3119929	1980 0 0.00	8.07130162	3.3023698	2270 54 36.03	*0.00284733165	6.33299247
Σ_2	8.3219930	2160 0 0.00	8.07130156	3.3023700	2090 54 35.95	*0.00284733161	6.33299197

---

* The corresponding numbers have been added.

E	l	G	G'	G''	θ	$\log \mathfrak{K}$	$\log \mathfrak{T}$	$\log \mathfrak{N}$
0	0.137 76127	0.587 23527	0.142 59981	0.003 67327	29° 50 12.97″	0.094 28087	0.396 79023	0.314 72571
15	0.135 93205	0.562 31468	0.142 74284	0.005 10263	30 41 37.56	0.100 17341	0.404 40450	0.323 20948
30	0.134 71786	0.534 56025	0.142 96704	0.006 07649	31 40 18.70	0.107 16555	0.413 42180	0.333 24961
45	0.134 46883	0.505 68767	0.143 21940	0.006 31437	32 42 44.77	0.114 92344	0.423 40404	0.344 35531
60	0.135 34362	0.477 61736	0.143 42737	0.005 69662	33 44 34.65	0.122 93987	0.433 69427	0.355 79389
75	0.137 20703	0.452 39646	0.143 51084	0.004 33149	34 40 36.18	0.130 49856	0.443 37414	0.366 54485
90	0.139 56539	0.432 06750	0.143 40426	0.002 57595	35 25 4.49	0.136 70353	0.451 30400	0.375 34554
105	0.141 62212	0.418 45750	0.143 09623	0.000 97183	35 52 44.73	0.140 65788	0.456 34998	0.380 94249
120	0.142 54931	0.412 88415	0.142 66320	0.000 07451	36 0 33.62	0.141 78785	0.457 79080	0.382 54019
135	0.141 92619	0.415 87654	0.142 25701	0.000 21775	35 48 50.91	0.140 09658	0.455 63407	0.380 14861
150	0.140 01227	0.427 06500	0.142 02490	0.001 34648	35 20 41.47	0.136 08370	0.450 51253	0.374 46742
165	0.137 58072	0.445 29837	0.142 03102	0.003 04495	34 40 10.49	0.130 43971	0.443 29885	0.366 46127
180	0.135 48161	0.468 90720	0.142 24327	0.004 73972	33 51 11.13	0.123 81665	0.434 81823	0.357 04266
195	0.134 30588	0.495 97000	0.142 57523	0.005 93116	32 57 11.97	0.116 76724	0.425 77304	0.346 98954
210	0.134 27836	0.524 51120	0.142 93246	0.006 33413	32 1 25.39	0.109 75153	0.416 75185	0.336 95547
225	0.135 30143	0.552 62582	0.143 23803	0.005 90863	31 6 52.56	0.103 14673	0.408 24135	0.327 48247
240	0.137 05610	0.578 56627	0.143 43948	0.004 81804	30 16 21.83	0.097 25105	0.400 63000	0.319 00464
255	0.139 11137	0.600 79667	0.143 51100	0.003 35627	29 32 27.98	0.092 29597	0.394 22222	0.314 86325
270	0.141 02020	0.618 04514	0.143 45226	0.001 86975	28 57 29.65	0.088 45847	0.389 25289	0.306 32243
285	0.142 39901	0.629 34391	0.143 28793	0.000 68684	28 33 26.40	0.085 87486	0.385 90395	0.302 58708
300	0.142 98478	0.634 06059	0.143 06246	0.000 06020	28 21 52.79	0.084 64926	0.384 31433	0.300 81370
315	0.142 67170	0.631 92420	0.142 83210	0.000 12415	28 23 50.37	0.084 85629	0.384 58290	0.301 11334
330	0.141 52485	0.623 03406	0.142 65313	0.000 87040	28 39 39.46	0.086 53835	0.386 76424	0.303 54673
345	0.139 76975	0.607 86141	0.142 56873	0.002 14548	29 8 52.62	0.089 69689	0.390 85723	0.308 11150
Σ_1	1.662 29562	6.318 55399	1.714 86964	0.038 13556	384 9 26.15	1.329 42669	5.016 04517	4.059 80799
Σ_2	1.662 29608	6.318 55323	1.714 87036	0.038 13555	384 9 26.54	1.329 42756	5.016 04627	4.059 80919

E	$\log N$	$\log P$	$\log Q$	$\log V$	J_1	J_2	J_3	$\log F_2$
0°	0.009 0498	0.862 7996	0.552 2553	0.548 9818	0.146 41488	+0.046 569 366	+0.007 078 444	n7.821 1843
15	0.041 5726	0.938 1720	0.610 8796	0.606 1455	0.147 99570	+0.053 809 593	+0.005 998 321	n7.883 3562
30	0.080 6578	1.028 2684	0.681 0018	0.675 0909	0.149 17691	+0.057 280 924	+0.004 274 648	n7.910 6349
45	0.124 8163	1.129 6769	0.759 8999	0.753 4266	0.149 62155	+0.056 746 961	+0.002 024 896	n7.907 2995
60	0.171 6324	1.236 8681	0.843 1970	0.837 0288	0.149 15409	+0.052 252 409	−0.000 597 633	n7.872 8570
75	0.217 4860	1.341 5449	0.924 3732	0.919 4294	0.147 84239	+0.044 134 510	−0.003 414 224	n7.801 7128
90	0.257 5171	1.432 5547	0.994 7294	0.991 6527	0.146 02955	+0.032 988 273	−0.006 232 935	n7.678 7174
105	0.286 2203	1.497 2527	1.044 5040	1.043 3053	0.144 27332	+0.019 614 339	−0.008 861 684	n7.459 6246
120	0.298 9083	1.524 8859	1.065 5419	1.065 4487	0.143 17010	+0.004 953 440	−0.011 121 317	n6.898 4006
135	0.293 5151	1.510 7656	1.054 4719	1.054 2014	0.143 10862	−0.009 985 226	−0.012 851 740	p7.132 1845
150	0.271 4379	1.458 2282	1.014 0442	1.012 4149	0.144 08811	−0.024 195 183	−9.013 952 904	p7.533 2200
165	0.236 7594	1.376 8369	0.951 6100	0.948 0753	0.145 73205	−0.036 737 898	−0.014 331 875	p7.719 4992
180	0.194 5715	1.278 4801	0.876 1594	0.870 9298	0.147 48132	−0.046 798 849	−0.013 968 920	p7.827 1282
195	0.149 5758	1.174 1125	0.795 9471	0.789 7501	0.148 82181	−0.053 732 494	−0.012 888 777	p7.888 5120
210	0.105 4451	1.072 2607	0.717 4326	0.711 1602	0.149 42892	−0.057 095 855	−0.011 165 046	p7.915 8746
225	0.064 7779	0.978 9193	0.645 2104	0.639 6416	0.149 20890	−0.056 671 026	−0.008 915 214	p7.912 1802
240	0.029 2993	0.898 0200	0.582 3492	0.577 9992	0.148 27058	−0.052 477 157	−0.006 292 610	p7.838 1383
255	0.000 1263	0.832 0547	0.530 8426	0.527 9163	0.146 86716	−0.044 770 588	−0.003 475 962	p7.807 9275
270	9.977 9738	0.782 5625	0.491 9640	0.490 3757	0.145 32896	−0.034 036 602	−0.000 657 227	p7.686 9473
285	9.963 3062	0.750 4867	0.466 5316	0.465 9576	0.143 99775	−0.020 965 237	+0.001 971 497	p7.473 1709
300	9.956 4277	0.736 3980	0.455 0694	0.455 0194	0.143 16554	−0.006 416 142	+0.004 231 074	p6.945 8150
315	9.957 5313	0.740 6137	0.457 8944	0.457 7910	0.143 02191	+0.008 631 431	+0.005 967 519	n7.101 9087
330	9.966 7118	0.763 2399	0.475 1405	0.474 4060	0.143 61483	+0.023 141 851	+0.007 062 502	n7.521 4470
345	9.983 9477	0.804 1353	0.506 7244	0.504 8724	0.144 83260	+0.036 096 092	+0.007 441 419	n7.711 8689
Σ_1	1.319 6325	13.074 5661	8.748 8847	8.710 5081	1.755 32379	−0.003 833 505	−0.041 341 924	
Σ_2	1.319 6348	13.074 5711	8.748 8890	8.710 5125	1.755 32376	−0.003 833 543	−0.041 341 924	

E	log F_3	log $(-R_0)$	log S_0	log W_0	log $\frac{1}{a}$ sin E $R^{(n)}$	log $\frac{1}{a}$ $S^{(n)}$
°						
0	p6.109 0979	0.004 9105	p9.066 4873	p8.414 8697	. . . .	p9.210 1316
15	p6.460 2026	0.035 6550	p9.178 8455	p8.426 8781	n9.592 1936	p9.322 3879
30	p6.639 0005	0.073 3408	p9.265 3003	p8.395 8122	n9.915 5544	p9.408 5439
45	p6.724 2291	0.116 8932	p9.327 8743	p8.269 9900	n0.109 1469	p9.470 6430
60	p6.737 5247	0.164 1819	p9.362 2754	p7.725 9934	n0.243 8632	p9.504 4261
75	p6.681 6660	0.211 5675	p9.357 0484	n8.250 7129	n0.337 9433	p9.498 4804
90	p6.543 7893	0.253 7196	p9.288 6962	n8.713 2631	n0.394 3818	p9.429 3504
105	p6.277 4254	0.284 2758	p9.100 9298	n8.963 5826	n0.409 1132	p9.240 8234
120	p5.628 2756	0.297 6983	p8.492 6019	n9.106 7994	n0.374 4076	p8.631 7806
135	n5.711 6481	0.291 6011	n8.839 9559	n9.168 3165	n0.279 6519	n8.978 5217
150	n5.826 7911	0.267 7639	n9.178 7411	n9.162 8714	n0.104 8299	n9.316 8371
165	p2.018 6378	0.231 0467	n9.303 5072	n9.104 3774	n9.781 8439	n9.441 3082
180	p6.120 9857	0.187 2653	n9.342 6978	n9.005 4644	. . . .	n9.480 3982
195	p6.468 4245	0.141 5414	n9.333 6689	n8.875 2645	p9.692 3386	n9.471 4699
210	p6.646 0095	0.097 6371	n9.293 1184	n8.717 5637	p9.934 7031	n9.431 2144
225	p6.730 8765	0.057 9988	n9.228 7915	n8.528 3769	p0.046 0496	n9.367 3573
240	p6.744 3892	0.024 0642	n9.142 6092	n8.288 3483	p0.100 7735	n9.281 7879
255	p6.689 4092	9.996 6187	n9.030 7075	n7.924 2395	p0.121 4561	n9.170 6011
270	p6.553 6008	9.976 0603	n8.879 6427	p6.132 6994	p0.116 7225	n9.020 3049
285	p6.292 7348	9.962 5865	n8.648 9777	p7.836 8958	p0.088 9623	n8.790 4097
300	p5.677 8477	9.956 3090	n8.129 7737	p8.090 7155	p0.035 9903	n8.271 9244
315	n5.684 4201	9.957 3171	p8.250 6252	p8.226 7829	p9.949 5708	p8.393 3939
330	n5.820 8856	9.965 7038	p8.696 6315	p8.315 3748	p9.807 9174	p8.839 8751
345	n4.135 8025	9.981 5566	p8.917 1054	p8.376 3691	p9.538 0952	p9.060 6478
Σ_1		*5.908 4737	*+0.010 66288	*−0.408 60954	*−3.538 4806	*+0.024 21404
Σ_2		*5.908 4840	*+0.010 66372	*−0.408 60959	*−3.538 4837	*+0.024 21607

E	$R_0 \sin v$ $+(\cos v+\cos E)\, S_0$	$-R_0 \cos v$ $+\sin v\left(\frac{r}{a}\sec^2\varphi+1\right) S_0$	log $W_0 \cos u$	log $W_0 \sin u$	$-2\,\frac{r}{a}R_0$
°					
0	+0.233 0866	+1.011 3711	p8.182 7238	p8.323 5442	2.008 9005
15	+0.008 7244	+1.126 4720	p7.976 5922	p8.397 7016	2.156 7748
30	−0.276 7659	+1.208 0644	p7.390 7836	p8.393 6800	2.353 9076
45	−0.629 8334	+1.222 6121	n7.483 4300	p8.264 1083	2.605 0539
60	−1.039 1050	+1.121 7558	n7.343 2314	p7.685 1177	2.908 8638
75	−1.458 6399	+0.850 8163	p8.054 3112	n8.138 0593	3.249 5836
90	−1.794 8636	+0.376 5263	p8.624 0711	n8.476 9772	3.587 1504
105	−1.921 5248	−0.266 8218	p8.935 1953	n8.507 7279	3.855 4443
120	−1.744 1606	−0.948 7539	p9.104 7730	n8.090 7696	3.983 0138
135	−1.279 0794	−1.488 0990	p9.162 4365	p8.381 6946	3.933 0324
150	−0.659 1294	−1.757 9567	p9.122 4932	p8.777 6916	3.727 0060
165	−0.049 0234	−1.748 8888	p8.993 4523	p8.905 4084	3.427 1881
180	+0.440 2788	−1.539 0947	p8.773 3185	p8.914 1389	3.099 2536
195	+0.772 8021	−1.227 4791	p8.429 0138	p8.845 5016	2.788 8931
210	+0.962 8351	−0.890 6639	p7.741 4585	p8.715 1260	2.519 0296
225	+1.044 3017	−0.573 1024	n7.715 6598	p8.523 1707	2.296 8106
240	+1.051 8039	−0.293 7729	n7.894 0916	p8.249 7786	2.121 1810
255	+1.012 9579	−0.055 9799	n7.720 7805	p7.816 2570	1.988 0041
270	+0.946 8650	+0.145 1147	p6.039 2095	n5.904 6342	1.892 7371
285	+0.864 9660	+0.317 7537	p7.806 3196	n7.396 1019	1.831 6679
300	+0.772 3975	+0.470 8818	p8.088 1599	n7.124 8096	1.802 3971
315	+0.669 1423	+0.612 5550	p8.221 5784	p7.414 0000	1.804 0170
330	+0.550 8294	+0.748 7960	p8.276 3278	p7.923 5602	1.837 1831
345	+0.409 2814	+0.882 4106	p8.266 6956	p8.175 5091	1.904 1728
Σ_1	−0.555 9282	−0.347 7320	*+0.405 70203	*+0.226 98821	31.840 6236
Σ_2	−0.555 9251	−0.347 7313	*+0.405 70141	*+0.226 98946	31.840 6376

* The corresponding numbers have been added.

The equation

$$\sin q \,.\, \tfrac{1}{2} A_1^{(s)} + \cos q \,.\, B_0^{(c)} = 0$$

gives the residual +0.000,000,033.

If m' is left indefinite, the resulting values of the differential coefficients are

$$\begin{array}{lll}
 & & \text{log coeff.} \\
\left[\frac{de}{dt}\right]_{00} = & -97592.^{\prime\prime}111\ m' & n4.989\,4447 \\
\left[\frac{d\chi}{dt}\right]_{00} = & -8920493.9\ \ m' & n6.950\,3889 \\
\left[\frac{di}{dt}\right]_{00} = & +71223.820\ m' & p4.852\,6253 \\
\left[\frac{d\Omega}{dt}\right]_{00} = & +\ 673299.06\ \ m' & p5.828\,2080 \\
\left[\frac{d\pi}{dt}\right]_{00} = & -8919313.6\ \ m' & n6.950\,3315 \\
\left[\frac{dL}{dt}\right]_{00} = & +5590689.3\ \ m' & p6.747\,4654
\end{array}$$

If the above value of m' be employed there results finally,

$$\left[\frac{de}{dt}\right]_{00} = -0.^{\prime\prime}013012279$$
$$\left[\frac{d\chi}{dt}\right]_{00} = -1.1893992$$
$$\left[\frac{di}{dt}\right]_{00} = +0.^{\prime\prime}00949\,65089$$
$$\left[\frac{d\Omega}{dt}\right]_{00} = +0.08977\,3204$$
$$\left[\frac{d\pi}{dt}\right]_{00} = -1.18924\,20$$
$$\left[\frac{dL}{dt}\right]_{00} = +0.74542\,525$$

These coefficients were computed to three significant figures by NEWCOMB ("*Secular Variations of the Orbits of the Four Inner Planets*," pp. 337 and 376). The results from the two methods may be compared as follows:

$$\begin{array}{rll}
 & \text{NEWCOMB} & \text{Method of GAUSS} \\
\left[\frac{de}{dt}\right]_{00} = & -0.^{\prime\prime}01301 & -0.^{\prime\prime}013012 \\
\left[\frac{di}{dt}\right]_{00} = & +0.00949 & +0.009497 \\
\sin i\left[\frac{d\Omega}{dt}\right]_{00} = & +0.00531 & +0.005313 \\
e\left[\frac{d\pi}{dt}\right]_{00} = & -0.00814 & -0.008138
\end{array}$$

The Flower Observatory, 1897 *July* 6.

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH EQUATORIAL AND FILAR MICROMETER AT GOODSELL OBSERVATORY, NORTHFIELD, MINN.,

BY H. C. WILSON.

[Communicated by the Director, WM. W. PAYNE.]

1896–97 Northfield M.T.		*	No. Comp.	☄ – *		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
				COMET 1889 V = 1896 VI.					
	h m s			m s	′ ″	h m s	° ′ ″		
Oct. 6	9 49 29	1	12 , 6	–0 6.72	–5 23.7	22 8 27.88	–16 47 1.8	8.946	0.884
7	9 19 52	1	9 , 6	+0 4.10	+1 17.9	22 8 38.68	–16 40 20.3	8.590	0.878
				COMET *f* 1896 = 1897..					
Nov. 23	6 57 6	2	12 , 6	+0 3.40	–2 13.2	19 57 18.91	+10 25 0.0	9.506	0.725
Dec. 2	6 14 16	3	9 , 6	–0 30.78	+4 13.0	. . . .	. . . .	9.496	0.757
	6 14 16	4	9 , 6	–1 34.88	+1 51.4	19 52 49.42	+ 5 38 24.8	9.496	0.757
8	6 31 53	5	9 , 6	–0 26.28	+3 18.7	19 50 57.97	+ 2 51 45.2	9.556	0.778
				COMET 1896 VII.					
Dec. 11	5 50 5	7	9 , 6	–0 54.54	–2 33.3	1 11 20.66	+ 5 18 6.1	*n*9.327	0.751
12	7 3 12	8	9 , 6	–1 3.30	–2 41.9	1 18 45.72	+ 4 52 32.3	*n*8.932	0.755
26	7 31 33	9	8 , 3	+3 46.37	+3 23.2	2 48 50.75	+ 0 35 52.5	*n*8.986	0.785
1897 Jan. 5	9 23 12	10	15 , 6	–0 13.39	–1 59.6	3 39 28.70	– 0 39 8.5	8.938	0.795
6	9 20 35	11	12 , 6	–0 24.08	–2 10.0	3 43 52.70	– 0 42 15.7	8.911	0.795
8	9 20 11	12	9 , 6	–1 49.23	–4 47.5	3 52 22.53	– 0 46 36.9	8.904	0.796
26	9 30 14	13	9 , 6	–0 37.79	+3 21.5	4 54 42.06	– 0 5 26.4	9.054	0.791
	9 30 14	14	9 , 6	–0 45.16	+6 12.0	4 54 42.27	– 0 5 27.5	9.054	0.791
28	9 28 21	15	8 , 6	+0 8.31	–6 29.0	5 0 25.53	+ 0 4 56.4	9.056	0.789
Feb. 22	10 0 0	16	est.	+0 1.0	+0 5	6 1 41.7	+ 2 36 25	9.359	0.772
Mar. 3	9 14 33	18	12 , 6	–0 25.75	–2 35.5	6 20 51.77	+ 3 26 40.8	9.261	0.764
	9 14 33	19	12	–0 48.70	. . .	6 20 51.78	. . . . .	9.261	0.764

Mean Places for 1896.0 and 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 8 30.38	+4.22 +4.20	−16 41 55.3	+17.2 +17.1	Washington Mural Zones 207, 67
2	19 57 13.19	+2.32	+10 27 1.5	+11.7	Yarnall (F) 8863
3	19 53 18	+2.36	+ 5 34	+ 9.1	DM. 5°4362
4	19 54 21.94	+2.36	+ 5 36 24.3	+ 9.1	Göttingen 5078, Munich 22519
5	19 51 21.82	+2.43	+ 2 48 18.8	+ 7.7	Micrometer-comparison with *6
6	19 52 28.04	+2.43	+ 2 42 38.2	+ 7.7	Göttingen 5068, Munich 22409
7	1 12 10.99	+4.21	+ 5 20 12.2	+27.2	Schjellerup 408
8	1 19 44.79	+4.23	+ 4 54 48.3	+26.9	Lalande 2579
9	2 44 59.82	+4.56	+ 0 32 7.4	+21.9	Schjellerup 788–9
10	3 39 40.40	+1.69	− 0 37 14.6	+ 5.7	Göttingen 638, Greenwich 10-yr. 580
11	3 44 15.08	+1.70	− 0 40 11.4	+ 5.7	Göttingen 649
12	3 54 10.04	+1.72	− 0 41 54.8	+ 5.4	Schjellerup 1240, Bonn VI, 626
13	4 55 18.00	+1.85	− 0 8 50.9	+ 3.0	Göttingen 872
14	4 55 25.58	+1.85	− 0 11 42.5	+ 3.0	Göttingen 874
15	5 0 15.37	+1.85	+ 0 11 22.6	+ 2.8	Göttingen 892, Schjellerup 1638
16	6 1 38.79	+1.87	+ 2 36 20.5	0.0	Micrometer-comparison with *17
17	6 3 35.32	+1.87	+ 2 30 57.3	0.0	Göttingen 1220
18	6 21 15.65	+1.87	+ 3 29 16.9	− 0.6	Micrometer-comparison with *20
19	6 21 38.61	+1.87	+ 3 26 43.5	− 0.6	Micrometer-comparison with *20
20	6 21 45.01	+1.87	+ 3 26 56.1	− 0.6	Bonn VI, 1252

REMARKS.

Nov. 23. Comet faint, with small central condensation. Easily measured. Round, about 2′ 30″ in diameter.

Dec. 11. Comet 1896 VII rather faint in moonlight, but can be seen in the 5-inch finder; about 5′ in diameter. In the 16-inch telescope the central condensation is strong, and there is a small star-like nucleus of about 12M. No tail is visible.

Dec. 26. Comet is bright, with distinct nucleus, about 12M. Head 5′ or 6′ in diameter. Short tail n. foll.

Jan. 8. Comet bright, very easily observed. Has a faint, broad tail, extending about 10′ from the nucleus, and spreading rapidly.

Jan. 26. Comet visible in 5-inch finder, but very diffuse there. In the 16-inch there is a small condensation, easy to bisect.

Feb. 22. Comet exceedingly faint and close to an 11M star. I caught sight of it at about 10h 0m local mean time, when it was about 5″ north and 15″ following the star. It was impossible to see the comet with any illumination of the wires at all, so the best I could do was to determine the place of the star. After the measures upon the star the comet could be seen with great difficulty, but had moved about 1′ to the east at 10h 40m.

March 3. Comet most exceedingly faint, but certainly seen, and certainly moving in R.A.

OBSERVATIONS OF THE SATELLITES OF *URANUS*,

By J. M. SCHAEBERLE.

The following observations of the satellites of *Uranus* were made with the 36-inch refractor of the Observatory. For the few unpublished measures of 1895, each tabulated position-angle is the mean of five separate measures, and each distance the mean of ten measures. For 1897 the tabulated results are the means of three measures for position-angle, and six measures for distance.

As a rule the character of the seeing was poor for those nights on which only *Oberon* and *Titania* were measured. *Ariel* and *Umbriel* are fairly easy objects when the seeing is best; but owing to the far south declination of *Uranus* these two faint satellites are only seen by glimpses when the atmospheric conditions are poor.

As average estimates, *Ariel* is about half a magnitude brighter than *Umbriel*, and *Oberon* about half a magnitude brighter than *Titania*. These differences are, however, not constant, but the observations are not sufficiently numerous to fix definitely the law of variation in brightness.

Ariel.

Date	Pacific Stand. Time	Position Angle	Dist.
1897	h m s	°	″
	13 15 28	358.45	
April 10	13 32 26	. .	14.48
	13 50 32	360.73	

Ariel. — Cont.

Date	Pacific Stand. Time	Position Angle	Dist.
1897	h m s	°	″
	13 53 30	287.65	
April 12	14 7 11	. .	13.90
	14 15 23	289.73	

Ariel. — Cont.

Date	Pacific Stand. Time	Position Angle	Dist.
1897	h m s	°	″
	13 19 47	43.04	
May 3	13 30 3	. .	14.92
	13 39 10	44.24	

Ariel. — Cont.

Date	Pacific Stand. Time	Position Angle	Dist.
1897	h m s	°	″
May 20	11 27 30	301.43	14.15
	11 36 10	. .	
	11 43 7	304.80	
May 21	11 54 40	88.02	14.11
	12 5 15	. .	
	12 17 13	89.98	
June 4	12 21 53	278.93	13.79
	12 31 26	. .	
	12 40 28	282.00	
June 6	9 44 8	344.13	14.60
	9 51 55	. .	
	9 58 22	344.67	
June 16	10 38 23	190.53	14.43
	10 52 35	. .	
	11 7 32	194.43	

Umbriel.

Date	Pacific Stand. Time	Position Angle	Dist.
1897	h m s	°	″
April 10	14 25 38	358.79	20.54
	14 48 30	. .	
	15 7 18	361.09	
April 12	14 26 43	172.80	20.74
	14 35 42	. .	
	14 45 40	174.17	
May 3*	12 38 17	191.32	19.76
	12 53 17	. .	
	13 8 28	189.27	
May 20	10 58 43	219.20	19.87
	11 8 52	. .	
	11 18 30	221.03	
May 21	11 19 30	311.18	20.01
	11 29 30	. .	
	11 39 48	312.65	
June 6	10 6 5	343.37	20.61
	10 16 14	. .	
	10 23 57	345.43	
June 16	9 57 10	43.17	20.17
	10 15 15	. .	
	10 28 57	44.77	

Titania.

Date	Pacific Stand. Time	Position Angle	Dist.
1895	h m s	°	″
June 13	9 34 34	101.07	29.39
	9 54 39	. .	
	10 11 42	103.09	
June 23	9 19 15	156.32	32.39
	9 32 0	. .	
	9 47 15	157.40	

Titania. — Cont.

Date	Pacific Stand. Time	Position Angle	Dist.
1897	h m s	°	″
April 10†	15 29 38	329.71	33.19
	15 43 21	. .	
	15 53 45	329.35	
April 12	13 18 23	47.00	31.96
	13 29 50	. .	
	13 39 40	47.50	
April 23	12 14 55	143.42	32.83
	12 26 10	. .	
	12 34 17	143.85	
May 3	11 27 13	192.67	33.48
	11 44 5	. .	
	11 59 50	193.10	
May 17	10 51 30	50.70	32.44
	11 4 28	. .	
	11 13 23	50.83	
May 20	10 29 33	174.30	33.93
	10 38 33	. .	
	10 47 10	174.87	
May 21	10 49 27	214.72	32.95
	10 56 59	. .	
	11 6 27	215.22	
May 28	9 57 40	146.43	33.55
	10 9 8	. .	
	10 20 7	147.37	
May 29	11 35 2	187.60	33.42
	11 54 5	. .	
	12 2 57	188.77	
May 31	10 40 17	270.67	31.34
	10 51 47	. .	
	11 3 20	271.87	
June 4	11 5 45	77.00	31.43
	11 18 30	. .	
	11 29 27	77.30	
June 6	10 35 38	198.00	33.17
	10 46 45	. .	
	10 53 8	198.03	
June 11	9 46 55	3.75	. .
June 16	9 29 32	207.87	32.56
	9 37 38	. .	
	9 44 53	208.70	

Oberon.

Date	Pacific Stand. Time	Position Angle	Dist.
1895	h m s	°	″
June 13	10 43 24	153.03	43.65
	10 56 11	. .	
	11 10 35	154.11	

Oberon. — Cont.

Date	Pacific Stand. Time	Position Angle	Dist.
1895	h m s	°	″
June 23	10 4 40	52.06	40.65
	10 19 46	. .	
	10 32 12	52.30	
1897			
April 12	12 47 57	35.63	42.92
	13 0 18	. .	
	13 10 45	35.50	
April 23	11 43 10	331.45	44.77
	11 55 27	. .	
	12 4 25	331.68	
May 3	12 5 10	237.24	42.83
	12 15 57	. .	
	12 26 33	237.57	
May 17	10 16 20	250.27	42.59
	10 29 21	. .	
	10 46 10	250.77	
May 20	9 54 17	331.40	44.99
	10 1 35	. .	
	10 17 3	331.80	
May 21	10 30 58	357.38	45.13
	10 38 35	. .	
	10 45 7	357.75	
May 28	9 24 43	183.77	45.01
	9 37 42	. .	
	9 50 27	184.47	
May 29	11 4 18	210.50	43.70
	11 16 35	. .	
	11 27 18	211.43	
May 31	10 7 43	265.87	42.41
	10 20 41	. .	
	10 31 40	266.27	
June 4	10 36 20	11.97	41.29
	10 47 1	. .	
	10 56 32	12.20	
June 6	11 2 42	94.50	42.15
	11 9 53	. .	
	11 17 13	94.80	
June 11	9 10 15	196.85	41.65
	9 23 33	. .	
	9 39 38	197.02	
June 16	9 4 7	333.20	41.36
	9 14 17	. .	
	9 23 3	333.70	

---

* Extremely faint.

† Three stars close together.

Lick Observatory, University of California, 1897 *June* 29.

SUNSPOT OBSERVATIONS,

MADE WITH THE 4-INCH EQUATORIAL OF THE LEANDER McCORMICK OBSERVATORY,

BY H. R. MORGAN.

1896	Time	Total		Fac. Gps.	Notes
		Gps.	Spots		
Aug. 22	1	3	18	–	cloudy
25	0	1	5	2	cloudy
26	0	2	8	–	cloudy
27	4	2	9	–	cloudy
28	0	1	9	–	cloudy
29	0	1	14	–	clear
31	0	2	9	1	clear
Sept. 1	3	3	6	2	cloudy
3	0	2	6	2	fair
4	1	3	7	–	cloudy
6	1	1	3	3	fair
7	0	3	10	3	hazy
8	0	3	24	4	cloudy
9	1	4	25	4	clear
10	0	4	30	4	clear
11	0	5	36	3	clear
12	2	4	38	2	cloudy
13	0	4	36	2	cloudy
15	4	1	33	1	cloudy
17	0	2	67	2	cloudy
18	0	3	69	3	fair
19	0	3	58	3	cloudy
22	0	4	16	3	cloudy
23	0	4	21	1	windy
24	1	2	18	2	fair
25	0	2	15	1	cloudy
30	0	2	3	3	fair
Oct. 3	1	1	2	4	cloudy
5	1	–	–	1	cloudy
6	4	1	1	2	cloudy
8	3	1	2	2	clear
9	3	1	5	2	clear
15	0	1	10	0	good
15	20	2	13	1	good
19	0	4	24	3	good
20	1	4	38	2	good
21	0	4	25	–	good
22	0	4	21	0	good
23	0	5	9	1	hazy
25	0	3	4	3	good
27	3	3	6	2	good
28	3	2	10	3	cloudy
29	0	1	7	4	fair
31	0	2	11	2	fair
Nov. 2	0	1	1	1	fair
3	0	1	4	2	fair
6	0	1	4	3	fair
7	1	2	12	1	fair
9	1	3	21	0	fair
10	0	3	12	0	cloudy
13	0	4	22	2	cloudy
14	23	–	22	–	cloudy
16	0	1	4	1	fair
17	0	1	2	1	fair
19	1	3	13	2	cloudy

1896–7	Time	Total		Fac. Gps.	Notes
		Gps.	Spots		
Nov. 24	0	1	4	2	fair
Dec. 3	0	3	23	3	fair
5	0	4	16	0	cloudy
7	0	5	20	1	cloudy
8	1	5	25	2	cloudy
9	0	4	20	1	fair
10	0	3	17	3	fair
11	0	3	14	3	fair
14	0	2	10	–	cloudy
17	0	4	14	2	fair
23	0	2	19	–	cloudy
24	0	3	13	1	fair
26	0	4	35	2	cloudy
28	0	3	28	5	fair
30	2	3	34	2	fair
31	3	4	14	3	fair
1897 Jan. 1	0	3	11	1	cloudy
5	2	4	20	1	cloudy
6	0	4	47	2	fair
8	0	3	55	3	fair
9	2	3	49	–	fair
11	1	1	35	3	cloudy
18	1	3	17	2	cloudy
19	1	6	21	–	windy
22	0	3	17	1	windy
23	0	3	18	4	windy
26	0	3	4	3	windy
28	0	2	7	2	windy
29	0	2	6	2	fair
30	0	5	16	4	fair
Feb. 3	1	4	44	2	fair
4	2	4	27	2	fair
8	3	1	7	1	cloudy
9	0	2	7	1	fair
12	4	1	1	1	cloudy
13	0	1	3	0	fair
16	1	1	7	0	cloudy
17	–	1	8	0	fair
19	0	1	1	2	cloudy
23	0	3	7	4	fair
24	0	2	6	3	fair
26	23	5	25	2	fair
Mar. 1	0	5	19	0	cloudy
3	1	4	29	0	cloudy
4	2	4	15	2	fair
10	0	5	7	4	windy
12	0	2	5	2	fair
13	1	2	4	0	fair
16	1	3	17	2	fair
20	1	1	1	1	fair
25	3	2	4	1	windy
26	1	2	5	4	windy
29	0	3	9	1	fair
Apr. 1	4	5	14	3	cloudy

1897	Time	Total		Fac. Gps.	Notes
		Gps.	Spots		
Apr. 2	0	3	4	–	cloudy
3	3	5	17	1	clear
5	0	6	26	5	clear
7	1	5	20	4	clear
9	2	5	18	5	cloudy
12	1	2	6	–	cloudy
14	0	2	6	3	cloudy
15	3	1	1	2	fair
16	0	1	6	2	fair
17	–	1	2	3	fair
19	0	2	15	2	fair
20	4	2	8	2	fair
21	0	1	5	1	hazy
22	3	0	0	5	fair
23	0	0	0	2	fair
24	3	0	0	0	cloudy
26	1	0	0	4	fair
27	3	1	2	6	fair
28	0	1	3	0	cloudy
29	4	2	7	1	cloudy
May 3	0	2	22	2	cloudy
4	4	2	31	0	cloudy
5	0	3	22	3	cloudy
6	4	2	24	2	fair
7	0	2	21	1	cloudy
8	4	2	9	3	fair
14	1	0	0	1	fair
15	4	0	0	0	cloudy
16	20	0	0	1	fair
17	20	0	0	1	fair
18	20	1	2	2	fair
19	20	1	5	2	fair
22	1	2	11	0	fair
24	1	2	6	0	cloudy
26	1	2	2	3	cloudy
27	0	2	4	2	hazy
28	0	2	6	3	fair
29	0	1	4	–	cloudy
31	2	2	11	0	fair
June 1	0	2	7	0	cloudy
2	0	2	3	0	cloudy
3	1	2	3	0	cloudy
4	0	2	3	0	fair
9	0	1	–	–	cloudy
12	2	1	6	0	cloudy
14	0	1	12	0	fair
15	2	1	2	0	fair
19	0	0	0	0	fair
21	0	1	1	2	fair
22	3	1	1	1	cloudy
24	0	1	1	0	cloudy
25	0	2	2	2	fair
29	3	–	–	–	cloudy
30	0	2	8	1	cloudy

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE VASSAR COLLEGE OBSERVATORY,

BY MARY E. TARBOX.

1897 Greenwich M.T.	*	No. Comp.	Planet — * Δα	Planet — * Δδ	Planet's Apparent α	Planet's Apparent δ	log pΔ for α	log pΔ for δ
				(313) *Chaldaea.*				
	h m s		m s	′ ″	h m s	° ′ ″		
April 1 14 51 50	1	8	+0 29.52	+4 26.8	14 7 58.37	− 3 8 51.7	*n*9.543	0.783
2 14 41 22	2	7	−0 12.12	−7 22.3	14 7 16.41	− 2 57 20.3	*n*9.551	0.782
19 14 41 3	3	8	−0 53.87	−7 49.1	13 53 35.71	+ 0 11 45.9	*n*9.387	0.766
20 14 52 54	3	8	−1 43.96	+2 9.0	13 52 45.63	+ 0 21 11.0	*n*9.336	0.765
21 13 47 54	4	12	+0 20.27	−9 55.0	13 51 57.31	+ 0 30 58.8	*n*9.490	0.764
29 16 47 10	5	8	+3 7.22	+0 3.1	13 45 30.38	+ 1 41 10.7	8.879	0.753
				(113) *Amalthea.*				
May 7 14 58 54	6	8	−0 14.56	+0 50.3	16 3 9.62	−12 3 29.6	*n*9.494	0.828
8 15 9 54	6	4	−4 8.32	+3 25.7	16 2 15.87	−12 0 54.2	*n*9.460	0.831
10 14 18 7	7	12	+0 1.21	+5 40.8	16 0 28.59	−11 56 0.2	*n*9.541	0.820
22 15 18 3	8	8	+1 28.38	−0 51.9	15 48 52.68	−11 32 41.0	*n*9.200	0.844

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	14 7 26.14	+2.71	− 3 12 58.9	−19.6	Weisse's Bessel XIV, 72
2	14 7 25.81	+2.72	− 2 49 38.4	−19.6	¼{Glas. I + Glas. II + Cord. + Cinc. 1890}
3	13 54 26.67	+2.92	+ 0 19 54.4	−19.4	Weisse's Bessel XIII, 895
4	13 51 34.10	+2.94	+ 0 41 13.2	−19.4	Weisse's Bessel XIII, 852
5	13 42 20.20	+2.96	+ 1 41 26.5	−18.9	Boss, Albany A.G.C., 4795
6	16 3 20.95	+3.24	−12 4 4.4	−15.5	Cambridge, Mass., Zone, 2 obs.
7	16 0 24.11	+3.27	−12 1 25.4	−15.6	Cambridge, Mass., Zone, 2 obs.
8	15 47 20.88	+3.42	−11 31 33.2	−15.9	Cambridge, Mass., Zone, 3 obs.

THE ASTRONOMICAL JOURNAL.

Referring to the notice on p. 128 (*A.J.* 400), the Editor regrets to announce that only one complete copy of Volume 1 of this *Journal* is now on hand, and this must be reserved for sale with a complete set. Several nearly complete copies of this volume are, however, yet to be obtained as follows, *if promptly ordered.*

Volume 1, two numbers missing	(nos. 1 and 6)	$12.00
" " four " "	(nos. 1, 4, 5 and 6)	9.00
" " five " "	(nos. 1, 3, 4, 5 and 6)	7.50
" " six " "	(nos. 1, 2, 3, 4, 5 and 6)	6.00

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NOTE ON PROFESSOR NEWCOMB'S DETERMINATION OF THE CONSTANT OF PRECESSION AND ON THE PARIS CONFERENCE OF 1896,

By LEWIS BOSS.

The operations indispensable for the accurate determination of star-positions in large numbers at successive epochs are precisely those which are required as a basis for the evaluation of nutation and precession. Without special observations for the determination of those constants the computer finds, ready to his hand, an abundance of the necessary material of observation. With a field so broad and free one might have supposed that, long before the present epoch, astronomy would have been provided with a value of the constant of precession which should fairly represent the possibilities of computation. But the very ease with which a close approximation to the value of this constant may be obtained appears to have deterred computers from really serious efforts.

When it was announced about a year ago that Professor Newcomb would undertake the determination of a constant of precession which had been adopted in advance, with a time limit, by the representatives of four national, or nautical, Astronomical Almanacs, no one anticipated that it would be possible for him to attempt a discussion which could be regarded as substantially exhaustive. The result as now presented (*A.J.*, 405) by Professor Newcomb, like all the productions of that eminent astronomer, is founded on clear-cut, logical, and novel methods of treatment which are not only most instructive to the reader, but which in this case are also very suggestive as to the necessity of further work upon the problem. The attentive reader must also perceive that no essentially new evidence has been imported into the treatment of this question.

The discussion of the precession-constant by Otto Struve in 1844 was based upon proper motions derived from comparison of Bradley with Dorpat observations of 1823. Mr. Ludwig Struve, in 1887, determined the proper motions which he employed by comparison of the places of Bradley with those obtained at Pulkowa for the mean epoch, 1855. Professor Newcomb employs the proper motions derived by Dr. Auwers through comparison of Bradley with Greenwich Catalogues of the approximate mean epoch, 1865; but he modifies these proper motions by certain systematic corrections, designed to reduce them to systematic harmony with his new fundamental star-positions.

It will be noticed that, in each of these three discussions, any errors which may exist in the star-positions of Bradley (so far as they have escaped detection, or have been neglected), may produce an error common to each of these determinations of the precession-constant. One might, therefore, assume that the only way to gain real increase of knowledge in regard to the precession-constant, would be through a determination in which Bradley's observations play a much less important part.

Many years ago, in order to satisfy his own curiosity on another point, the writer had occasion to execute extensive tentative computations, which, at the same time, enabled him to consider what course might be most advantageous in the determination of the constant of precession. As any one might have expected, it became clear that an element of prime importance in this determination is the number of series of observations brought into the discussion. Systematic errors of star-catalogues are usually of the same order of magnitude as the casual errors of individual star-places. It usually happens that, from a relatively limited number of such individual places compared with imperfect standards, there must be determined not only the coefficients of systematic correction, but also its trend, or law; and it is this latter operation which introduces the chief uncertainty in that class of discussions. It is impossible, therefore, wholly to rid any one star-catalogue of its systematic errors. The only hope of reasonable immunity from such errors in the mean is, of course, through the use of many catalogues. Of equal importance is it that the discussion should embrace as many stars as possible, in order that the manner of dealing with the larger, or abnormal, proper motions may become more nearly a matter of indifference. As to systematic correction of the observations, it was seen that the observations of Lalande, Bessel, Argelander, Schjellerup and others, require correction by zones; and that this process could probably be accomplished in a reasonably satisfactory manner through the results of further observations of selected lists of telescopic stars, and after the publication of the Paris Catalogue, the zones of the *Astronomische Gesellschaft,* and some other series of observations useful for the purpose.

There are two points of view in which the determination of the precession-constant may be regarded. One considers the precession as it is manifested in the motion of the celestial pole among the stars; and the other as it is manifested in the motion of the equinox along the ecliptic. These points of view are, of course, not really distinct, yet one, or the other, may receive emphasis in the method of computation according to the predilections of the computer. In the various discussions, hitherto, the determination of the precession-constant has been made to depend almost wholly upon direct observation of the motion of the equinox, in so far as it is represented by the constant, m, since it has virtually depended upon the observed right-ascensions of a very greatly preponderating number of stars within thirty degrees of the ecliptic, or equator. As nearly as I can infer, the three determinations of precession which are here cited, when reduced to the equinox (N_1) employed by Professor Newcomb, would be about as in the last column of the annexed statement, where the values of luni-solar precession for 1850, as originally determined, are given for purposes of comparison.

	As Computed	Corr. to N_1
	″	″
O. Struve (1844)	50.382	50.378
L. Struve (1887)	50.354	50.364
S. Newcomb (1897)	50.368	50.368

The two later values would have agreed still closer but for an attempt by Professor Newcomb to reconcile the constant determined by him to an equinox not quite identical with N_1.

Mr. Ludwig Struve has shown in his paper (pp. 20 and 22 of *Best. der Const. der Praec.*: 1887), that the constant determined by him is practically independent of any assumption as to the parallactic effect of solar motion; and this conclusion is confirmed in Professor Newcomb's recent paper, by comparing results derived from different methods. Professor Newcomb's various results are, therefore, not really independent contributions to our knowledge of the true value of the constant of precession; they simply show that, when the attempt is made to derive the precession from star-positions observed by Bradley, and compared with a modern series of observations, it makes practically little difference whether the solar motion is considered, or not.

Professor Newcomb finds a difference of 0″.9 between the constant of precession (centennial) which he derives from considering respectively the right-ascensions and declinations of stars. Though this discrepancy is really not vitally important in relation to the probable error of determination, yet it is worthy of some attention. Mr. Ludwig Struve found this difference to be 0″.03, a difference which is practically insignificant. If, however, Mr. Struve had used the more accurate equinox adopted by Professor Newcomb, the discrepancy between his determinations of the centennial constant from right-ascensions and from declinations would have been more than 1″.0, (again not a very anomalous difference in relation to the probable error), but in a sense opposite to that which Professor Newcomb finds. The most natural way to account for this is to suppose that, in one or both of the discussions, the results may have been materially influenced by errors in right-ascension which are a function of the declination, and in declination which are a function of the right-ascension. Professor Newcomb presents evidence to show that his determination is probably not affected with material errors of the first of these classes.

The values of X, Y and Z, coordinates of solar motion derived by Professor Newcomb, place the solar apex at R.A., 274°.2, and Decl., +31°.2, in substantial agreement with other researches founded on the star-positions from Bradley's observations compared with modern places. At the same time this position of the solar apex is at variance with the more elaborate determinations of recent times that are founded upon the discussion of many stars having large proper motions, whether observed by Bradley, or not. The origin of this discrepancy, and the bearing of it upon the apparent value of the precession-constant is in need of an examination much more extensive and exhaustive than it has yet received.

Doubtless Professor Newcomb has sufficiently exhausted the consideration of the evidence as to the true value of the precession-constant which may be derived from the comparison of Bradley's star-places with those of Greenwich for the mean epoch 1865; but it seems to me that this is only a small part of the evidence which ought to be considered. To call upon astronomers to endorse the constant of precession which Professor Newcomb has found in this way, appears to me almost as unreasonable as it would be to ask them to adopt a value of the constant of solar parallax derived from a partial discussion of the material available through a single method. The method and material selected might be of the best, and the result might be near the truth; but there would certainly be lacking the essential element necessary to impart confidence in the result. How much such a determination may be in error, though emanating from the most competent authority, and received with universal confidence, is illustrated in the history of Encke's determination of the solar parallax.

The recent Paris Conference upon the subject of astronomical constants was apparently designed to bring about economy of labor through a certain degree of cooperation in the preparation of the publications represented. The publications represented were the four Astronomical, or Nautical Almanacs, which astronomers have been accustomed to use in their computations. Consequently the decisions of this Conference are matters pertinent for public discussion.

I have already indicated some of the reasons why I think that the predetermined precession coefficient of the Conference cannot, at present, be accepted. But the matter does not end there. The majority of astronomers would probably say that the labors of Dr. NYRÉN, Dr. CHANDLER and others, pointing to a value of the aberration-constant near 20″.50, are entitled to great weight. The value, 20″.55, recently obtained from special observation by Professor DOOLITTLE (*A.J.*, 406) can by no means be set aside as abnormal, but is entitled to respectful consideration. On the other hand, some astronomers might contend for a value of the aberration-constant even lower than 20″.47, the value adopted by the Paris Conference. Now it seems to me that there is here an intolerable uncertainty which must be settled in the same way in which the analogous uncertainty, of thirty years ago, concerning the solar parallax was settled, namely, by a general and determined attack upon the problem. To say that there is no necessity for this attack, and to attempt to quiet the discussion by the arbitrary adoption of a certain value of the constant now, seems to me altogether premature, and against the best interests of scientific investigation.

No great inconvenience can arise from the retention of the STRUVE–PETERS constants for a few years longer, until we are in a better position to agree upon some value of those constants likely to satisfy astronomers for a considerable term of years. The difference between the aberration-constant in present use and that proposed by the Conference is only 0″.025; the corresponding difference for the precession-constant is 0″.008; and, for the constant of nutation, the difference is 0″.014. These proposed changes are practically insignificant in relation to all observations of a differential character; and, even if we grant that they are the actual corrections required, no serious harm can result if the use of them be deferred, since it is morally certain that astronomers will not rest satisfied with the present state of our knowledge in reference to the constants of precession and aberration.

As to the constant of solar parallax, after the strenuous exertions of the past twenty-five years, there has been a natural growth of opinion in favor of a value very near 8″.80, as best representing the resultant of the mass of evidence which has been presented. With this constant, the case is very different from that which concerns the aberration. With the former, the period of extremely active investigation is, in all probability, terminated for the present; with the latter, in view of its connection with the constants of latitude-variation, a period of activity in its investigation, to all appearances, has set in.

If it be assumed that general acceptance of the same constants of reduction is desirable, and that frequent changes in these constants is to be deprecated, there seem to be very good reasons for deferring a change in the constants of star-reduction until there is good prospect that such change is to be more than a temporary one. But, assuming that the agreement of the Paris Conference is final, so far as the four almanacs are concerned, it does not seem to me to follow that the majority, or that even a very considerable minority, of astronomers is bound either by professional courtesy, or by necessity, to adopt the new constants in their computations. In this country the case is very simple. It should be understood that the United States Naval Observatory, with the Nautical Almanac office incorporated in it, is simply a bureau of the Navy. The responsible duties of those offices are discharged by officers of the Navy, the larger portion of whom do not pretend to a knowledge of astronomy. American astronomers have no voice, direct or indirect, in the policy or conduct of those institutions, for which they are in no way responsible in the slightest degree. Equally, it is obvious that no officer of that bureau is entitled, in his official capacity, to represent American astronomy. The adoption of new astronomical constants by the American Nautical Almanac office affects only the American Navy and merchant marine.

Furthermore, there must necessarily be some variety of practice during a transition period like this. Those who are, or shall be, engaged on a series of observations begun before 1901, and to continue after that date, must exercise some freedom of choice. They may use the old constants throughout, or they may adopt a set of constants for themselves, since it is desirable that the computations for any given series of observations should rest upon the same constants throughout. Doubtless there will be a demand for the publication of data for star-reductions on the basis of the old constants for some years after new constants shall have been definitively adopted; and, if, in the present instance, the almanacs do not perform this necessary service, some other agency must be devised for the purpose.

In fact, it has long seemed to me that observers with meridian-instruments need an ephemeris-publication specially designed for their use. Standard catalogues of stars prepared for the Almanacs have always been behind the easy possibilities of computation. Really, or ostensibly, these catalogues have usually been prepared for use in navigation, or geodesy. Apparently, that preparation, in some instances, must have proceeded under a superior official observation, which rendered it politic, if not compulsory, to establish the weighting of observations upon a strictly national basis, — as if a departure from this system might lead to the charge of national disloyalty. From this state of things meridian-observers have suffered much; and it is likely that the Paris Conference may become the initial factor toward inaugurating broader views, however faulty any of its individual conclusions may seem to be.

Many observers have noticed how the differential process in meridian observation would be facilitated, and how, at the same time, the accuracy of the observed results in every respect could be increased in a remarkable degree, by a suitable increase in the number and accuracy of star-places in the standard catalogues. We are now on the very threshold of greater possibilities as to differential meridian work, for which there is to be a greater demand than ever before.

As every one must have perceived, in the astronomy of the future, that which relates to the stars must gain in relative importance over that which relates to the solar system. Therefore, it is very desirable to introduce improvements in the computing appliances designed for the use of observers with meridian-instruments. Attempts at such improvements can be made, I think, in the reasonable hope of diminishing the labor of computation in differential work by one-half, and of increasing the weight of the results to at least double, in comparison with the ordinary experience of former times.

Differential observation with meridian instruments can be made as easy for the occasional observer, as it now is for observers with extra-meridian instruments; and when this becomes a fact, we may hope that many idle meridian-circles now rusting from disuse, may be brought into active operation for a part of the time at least.

In the near future, therefore, it may be assumed that the question of astronomical constants, so far as it relates to star-reductions, will become a question for the authors of special publications in the interests of meridian-observers to decide; and, therefore, one to be decided, if definitely in favor of uniformity, by the common consent of astronomers after due opportunity for examination of the evidence presented.

It is a serious question whether the present astronomical almanacs ought not to be looked upon as unsuited to modern requirements; and whether the needs of the navigator, of the observer of occasional phenomena in general, of the observer and computer who is concerned with the bodies of the solar system, of those who are engaged in geodetic operations, and of those who observe the stars with meridian-instruments, — whether the needs of each of these ought not to be considered separately, and with more particular care than some of them have hitherto received. Nor is it necessary that the number of such publications should be restricted, or regulated otherwise than by the demand for them. It seems to me that, if the almanacs adhere to the conclusions of the Paris Conference (as it is to be presumed they will) and become four editions of one almanac, that this determination may simply serve to hasten the establishment of special publications, such as I have indicated, — or at least of a publication designed for the use of observers with meridian-instruments. Therefore, it also seems unnecessary to assume that the proceedings of the Paris Conference are irrevocably to decree a set of astronomical constants, unless astronomers, after due consideration, find themselves in full accord with those conclusions. Should those conclusions not meet with the general approbation of astronomers, it would be incumbent upon them to institute active measures with the object of providing themselves with what they need.

DOUBLE-STAR MEASURES,

MADE AT THE OBSERVATORY OF THE UNIVERSITY OF MINNESOTA,

By S. B. SOULÉ.

$\Sigma 106$ $8^{M}.5$ $8^{M}.6$

$\alpha = 1^h\,11^m\,14^s$, $\delta = -7°\,41'$

	°	″
1896.609	307.5	4.54
.612	307.0	5.00
.614	307.4	4.77
1896.612	307.3	4.77

Fixed.

$\Sigma 1924$ $9^{M}.5$ $9^{M}.7$

$\alpha = 15^h\,9^m\,48^s$, $\delta = +26°\,8'$

1896.464	304.6	15.78
.540	305.1	14.84
1896.502	304.8	15.31

Fixed.

$\Sigma 1992$ ... ...

$\alpha = 13^h\,55^m\,33^s$, $\delta = +11°\,57'$

	°	″
1896.464	328.4	5.08
.603	321.7	6.12
1896.534	325.0	5.60

Probably fixed.

$\beta 815$ $8^{M}.5$ $10^{M}.2$

$\alpha = 16^h\,23^m\,54^s$, $\delta = +43°\,8'$

1896.543	338.4	8.86
.631	337.2	8.60
1896.587	337.8	8.73

Change probably due to proper motion of principal star.

λ *Ophiuchi* $5^{M}.0$ $6^{M}.0$

$\alpha = 16^h\,25^m\,52^s$, $\delta = +2°\,12'$

	°	″
1896.442	46.3	2.18
.565	50.5	1.58
1896.504	48.4	1.88

$\Sigma 2057$ $9^{M}.5$ $9^{M}.5$

$\alpha = 16^h\,27^m\,9^s$, $\delta = +19°\,30'$

1896.499	262.9	5.48
.540	262.2	4.93
1896.520	262.6	5.20

Fixed.

70 *Ophiuchi* $4^{M}.0$ $5^{M}.0$

$\alpha = 18^h\,0^m\,23^s$, $\delta = +2°\,32'$

	°	″
1896.148	289.1	2.37
.540	288.1	2.46
.790	287.0	2.44
1896.593	288.1	2.42

$\Sigma 2393$ $7^{M}.4$ $9^{M}.6$

$\alpha = 18^h\,41^m\,47^s$, $\delta = +38°\,12'$

1896.448	24.0	13.76
.516	24.5	14.00
.518	23.1	13.55
.538	20.2	13.45
.565	22.1	12.79
1896.517	22.8	13.51

Σ2416 $7^{M}.9$ $10^{M}.4$

$\alpha = 18^{h}\,49^{m}\,44^{s}\ ,\ \delta = +51^{\circ}\,12'$

	°	″
1896.516	154.6	16.90
.518	155.8	16.93
.524	155.5	17.15
.538	157.4	17.76
1896.524	155.8	17.20

Distance increasing.

β142 $7^{M}.5$ $7^{M}.6$

$\alpha = 19^{h}\,22^{m}\,37^{s}\ ,\ \delta = -12^{\circ}\,21'$

1896.502	330.5	1.39
.521	332.2	1.84
1896.512	331.4	1.62

Σ2564 $8^{M}.5$ $9^{M}.4$

$\alpha = 19^{h}\,36^{m}\,2^{s}\ ,\ \delta = +63^{\circ}\,36'$

1896.516	169.2	9.35
.518	171.2	9.76
.524	169.0	10.21
.538	171.9	10.22
1896.524	170.3	9.89

Σ2615 $7^{M}.3$ $10^{M}.2$

$\alpha = 19^{h}\,58^{m}\,10^{s}\ ,\ \delta = +8^{\circ}\,7'$

1896.508	317.7	9.67
.536	318.1	9.45
.543	317.8	9.94
.565	318.3	10.09
1896.538	318.0	9.79

Σ2649 $7^{M}.5$ $9^{M}.1$

$\alpha = 20^{h}\,8^{m}\,22^{s}\ ,\ \delta = +31^{\circ}\,46'$

1896.480	152.5	23.56
.565	150.9	24.44
.590	151.2	24.58
1896.545	151.5	24.19

Σ2658 $7^{M}.5$ $9^{M}.7$ $9^{M}.6$

$\alpha = 20^{h}\,11^{m}\,7^{s}\ ,\ \delta = +52^{\circ}\,48'$

A and *B*.

	°	″
1896.480	118.7	5.02
.497	113.6	5.61
.590	117.8	5.78
.593	115.4	5.62
.601	116.3	5.48
1896.552	116.1	5.50

Angle diminishing.

A and *C*.

1896.480	210.3	43.11
.497	210.1	44.07
.590	210.6	43.84
1896.522	210.3	43.67

Change in angle and distance.

Σ2746 $7^{M}.8$ $8^{M}.5$

$\alpha = 20^{h}\,58^{m}\,0^{s}\ ,\ \delta = +38^{\circ}\,52'$

1896.521	296.9	1.18
.524	294.3	1.11
.554	298.4	1.29
1896.533	296.5	1.19

Σ2759 $7^{M}.9$ $8^{M}.4$

$\alpha = 21^{h}\,2^{m}\,19^{s}\ ,\ \delta = +32^{\circ}\,3'$

1896.521	323.6	15.62
.578	324.0	16.05
.581	323.1	15.40
.609	323.4	15.84
1896.572	323.5	15.73

61 *Cygni* ... ...

$\alpha = 21^{h}\,2^{m}\,9^{s}\ ,\ \delta = +38^{\circ}\,12'$

1896.502	123.7	22.19
.527	125.9	22.41
1896.514	124.8	22.30

S 790 69 *Cygni* $\overset{M}{5.5}$ $\overset{M}{10.2}$ $\overset{M}{7.1}$

$\alpha = 21^{h}\,21^{m}\,42^{s}\ ,\ \delta = +36^{\circ}\,14'$

A and *B*.

	°	″
1896.614	30.2	33.30
.628	29.9	34.10
1896.621	30.0	33.70

A and *C*.

1896.612	98.0	54.32
.614	97.9	54.20
.620	97.2	54.08
.628	97.7	53.57
1896.618	97.7	54.04

Only double seen in this region. Does not agree with SOUTH's measure of 1825, but agrees approximately with those of LEAVENWORTH's made at about the same time.

Σ2799 $7^{M}.0$ $7^{M}.2$

$\alpha = 21^{h}\,24^{m}\,1^{s}\ ,\ \delta = +10^{\circ}\,39'$

1896.497	300.6	1.59
.527	296.3	1.32
.554	295.4	1.63
1896.526	297.4	1.51

S 799 79 *Cygni* $5^{M}.5$ $6^{M}.2$

$\alpha = 21^{h}\,39^{m}\,18^{s}\ ,\ \delta = +37^{\circ}\,49'$

1896.521	59.6	153.08
.524	59.4	152.85
.579	59.7	152.93
.581	59.7	152.93
.601	59.6	153.27
1896.561	59.6	153.01

Agrees with SOUTH's measure.

Σ2828 $7^{M}.8$ $8^{M}.4$

$\alpha = 21^{h}\,44^{m}\,27^{s}\ ,\ \delta = +2^{\circ}\,55'$

A and *B*.

	°	″
1896.612	141.0	27.59
.634	141.4	27.16
.729	141.5	27.20
1896.658	141.3	27.12

S 800 $6^{M}.2$ $6^{M}.8$

$\alpha = 21^{h}\,30^{m}\,55^{s}\ ,\ \delta = +62^{\circ}\,9'$

1896.502	145.0	62.98
.554	145.8	63.26
.779	145.7	62.75
1896.546	145.5	63.00

OΣ(App.) 228 $6^{M}.9$ $8^{M}.0$

$\alpha = 21^{h}\,56^{m}\,51^{s}\ ,\ \delta = +4^{\circ}\,18'$

1896.590	27.2	75.76
.601	27.0	75.50
.609	27.2	75.89
.628	27.3	76.14
1896.607	27.2	75.82

S 808 $7^{M}.4$ $8^{M}.5$

$\alpha = 22^{h}\,20^{m}\,21^{s}\ ,\ \delta = -20^{\circ}\,45'$

1896.631	150.4	7.03
.634	152.8	6.78
.729	150.9	6.90
1896.665	151.4	6.90

ζ *Aquarii* ... ...

$\alpha = 22^{h}\,23^{m}\,39^{s}\ ,\ \delta = -0^{\circ}\,35'$

1896.480	321.0	2.65
.497	321.7	2.75
.518	323.4	3.60
.521	319.0	2.89
1896.504	321.3	3.00

Σ3046 $8^{M}.2$ $8^{M}.6$

$\alpha = 23^{h}\,51^{m}\,17^{s}\ ,\ \delta = -10^{\circ}\,3'$

1896.609	247.9	3.29
.614	246.0	3.31
1896.612	247.0	3.30

Slow binary.

DOUBLE-STAR MEASURES,

MADE AT THE OBSERVATORY OF THE UNIVERSITY OF MINNESOTA,

BY MARY S. WAGNER.

ξ *Scorpii* ... ...

$\alpha = 15^{h}\,58^{m}\,52^{s}\ ,\ \delta = -11^{\circ}\,5'$

A and *B*.

	°	″
1896.499	215.3	1.50
.502	213.4	1.45
.524	216.7	1.14
.527	214.2	1.38
1896.513	214.9	1.37

ξ *Scorpii* ... ... — Cont.

$\alpha = 15^{h}\,58^{m}\,52^{s}\ ,\ \delta = -11^{\circ}\,5'$

A B and *C*.

	°	″
1896.499	66.9	7.46
.502	62.8	7.46
.524	62.5	7.40
.527	61.7	7.56
1896.513	63.5	7.47

λ *Ophiuchi* $5^{M}.0$ $7^{M}.0$

$\alpha = 16^{h}\,25^{m}\,52^{s}\ ,\ \delta = +2^{\circ}\,12'$

	°	″
1896.565	49.3	1.71
.573	47.5	1.97
.581	51.2	1.56
.587	44.5	1.58
1896.576	48.1	1.70

70 *Ophiuchi* $4^{M}.0$ $5^{M}.0$

$\alpha = 18^{h}\,0^{m}\,23^{s}\ ,\ \delta = +2^{\circ}\,32'$

	°	″
1896.581	289.3	2.71
.587	287.2	2.10
.603	293.1	2.17
1896.590	289.9	2.33

NOTES ON VARIABLE STARS, — No. 19,

By HENRY M. PARKHURST.

Results of Observations.

No.	Star	Phase	Observed Date		E	Corr.	W	Mag.	Factors			Remarks
			Julian	Calendar								
				1896-7							d	
(2903)	— *Cancri*	–	–	–	–	–	–	–	–	–	–	No appreciable fluctuation
2946	*R Cancri*	Min.	1142	Aug. 5	46	–	E	–	–	–	–	Identification uncertain
2976	*V Cancri*	Min.	3968	Feb. 12	35	–13	2	13.0]	–	–	–	
3060	*U Cancri*	Max.	4127	July 21	53	–	E	–	–	–	–	Invisible in May
3170	*S Hydrae*	Max.	3994	Mar. 10	57	–14	6	7.79	0.94	0.94	45	
3184	*T Hydrae*	Min.	4034	April 19	50	–	E	–	–	–	–	Midway; probably later
3264	*W Cancri*	Max.	3969	Feb. 13	6	–11	8	7.49	0.17	0.26	10	Much brighter than last year
3425	*X Hydrae*	Min.	4104	June 28	7	–	E	–	–	–	–	Midway; probably later
3477	*R Leonis min.*	Min.	3981	Feb. 25	32	+ 7	4	12.5	1.4	1.4	43	
3493	*R Leonis*	Min.	4035	April 20	164	–27	9	10.85	0.90	4.0	38	Fluctuation
3567	*V Leonis*	Max. A	4000	Mar. 16	20	–12	8	8.73	0.40	0.70	18	
"	"	Max. B	4017	April 2	20	+ 5	8	8.48	0.20	0.33	13	See note below
3712	*U Leonis*	–	–	–	–	–	–	–	–	–	–	See note below
3881	*V Hydrae*	Max.	4066	May 21	15	+208	Sr	6.9	–	–	–	Compared with Second Catal.
3890	*W Leonis*	Max.	3905	Dec. 11	23	–	E	–	–	–	–	Before predicted time
3934	*R Crateris*	–	–	–	–	–	–	–	–	–	–	Perhaps brightening in May
—	DM. +10°2233	–	–	–	–	–	–	–	–	–	–	"Missing star"
—	DM. + 7°2425	–	–	–	–	–	–	–	–	–	–	"Missing star"
3994	*S Leonis*	Max.	4022	April 7	70	–40	4	–	–	–	–	Correction nearly unchanged
4160	*T Leonis*	Min.	4074	May 29	–	–	3	–	–	–	–	See note below
4300	*X Virginis*	–	–	–	–	–	–	–	–	–	–	See note below

3567. The observations of April 2 and 3 appear to correspond with the "outburst" observed in 1891 (*A.J.* 256), and to indicate a fluctuation independent of the normal light-curve.

3712. I have never seen, in eight different years of observation, any certain variation in the 12^M star at or near the place of *U*, nor any other star near it.

4160. The star observed is that specified in *A.J.* 356. Its variation appears, from these observations to have a period of about 60 days; but this is not sustained by the former observations. I have seen no decided fluctuation in stars nearer the catalogue place for 4160, although I have carefully watched these stars since 1887.

4300. A small fluctuation, but period probably short.

The two "missing stars" are from the Third Catalogue, and sufficiently identified.

Individual Observations.

Including Observations by ARTHUR C PERRY.

(2903) — *Cancri.*

(Continued from 350.)

Julian	Calendar		Mag.
	1897		
4067.6	May	22	12.9
4074.6		29	12.8

2916 *R Cancri.*

(Continued from 377.)

Julian	Calendar		Mag.
	1897		
4060.6	May	15	10.8]
4063.6		18	10.9]
4067.6		22	11.0
4070.6		25	10.98_2

2976 *V Cancri.*

(Continued from 350.)

Julian	Calendar		Mag.
	1897		
3930.6	Jan.	5	12.0
3980.6	Feb.	24	12.6]
3988.6	Mar.	4	13.0]
4010.5		26	11.6

3060 *U Cancri.*

(Continued from 350.)

Julian	Calendar		Mag.
	1897		
4060.6	May	15	11.4]
4063.6		18	12.0]
4070.6		25	12.8]

3170 *S Hydrae.*

(Continued from 384.)

Julian	Calendar		Mag.
	1897		
3935.6	Jan.	10	9.1
3965.6	Feb.	9	8.5
3969.6		13	8.13_2
3983.5		27	8.12_2
3994.6	Mar.	10	7.69_2
4008.6		24	7.99_2
4014.5		30	8.38_2
4017.5	Apr.	2	8.39_2

3184 *T Hydrae.*

(Continued from 384.)

Julian	Calendar		Mag.
	1897		
3984.5	Feb.	28	11.3

3184 *T Hydrae.* — Cont.

Julian	Calendar		Mag.
	1897		
3995.5	Mar.	11	11.54_2
4010.5		26	13.0
4016.6	Apr.	1	13.4
4033.6	April	18 to	
4067.6	May	22	13.5]
	4 dates		

3264 *W Cancri.*

(Cont. from 384. Comp Stars 384)

Julian	Calendar		Mag.
	1897		
3935.6	Jan.	10	12.0 :
3964.6	Feb.	8	8.2
3965.6		9	7.81_2
3967.5		11	7.38_2
3969.6		13	7.45_2
3970.6		14	7.42_2
3975.6		19	8.30_2
3980.5		24	8.15_2

3425 *X Hydrae.*

(Cont from 384. Comp. Stars 350)

Julian	Calendar		Mag.
	1897		
4060.6	May	15	9.8]
4063.6		18	9.8]
4067.6		22	11.2

3477 *R Leonis min.*

(Continued from 384.)

Julian	Calendar		Mag.
	1897		
3932.6	Jan.	7	10.9
3980.6	Feb.	24	12.3
3988.6	Mar.	4	12.5
4010.5		26	11.8

3493 *R Leonis.*

(Continued from 384.)

Julian	Calendar		Mag.
	1897		
3963.5	Feb.	7	8.5
3984.5		28	9.2
3994.6	Mar.	10	9.01_2

3493 *R Leonis.* — Cont.

Julian	Calendar		Mag.
	1897		
3997.6	Mar.	13	9.92
4005.6		21	9.6
4009.6		25	9.85_2
4017.6	Apr.	2	10.19_2
2026.6		11	10.94_2
4033.6		18	10.3
4034.6		19	11.00_2
4045.6		30	10.3
4050.5	May	5	10.58_2
4051.5		6	10.89_2
4067.6		22	10.78_2
4076.6		31	10.89_2

3567 *V Leonis.*

(Continued from 326.)

Julian	Calendar		Mag.
	1897		
3935.6	Jan.	10	11.7]
3963.6	Feb.	7	10.6 :

3567 *V Leonis.* — Cont.

Julian	Calendar	Mag.
	1897	
3984.5	Feb. 28	10.0
3991.6	Mar. 7	8.87$_2$
3994.6	10	9.2P
3997.5	13	9.17$_2$
4005.5	21	8.90$_2$
4005.6	21	9.0P
4008.6	24	8.52$_2$
4009.6	25	9.00$_2$
4010.5	26	9.30$_2$
4010.6	26	9.2P
4012.5	28	8.75$_2$
4013.6	29	9.07$_2$
4014.6	30	9.2P
4016.6	Apr. 1	9.6P
4017.6	2	7.86$_2$
4018.5	3	8.60$_2$
4026.5	11	9.43
4026.6	11	9.7P
4031.6	16	9.53$_2$
4032.6	17	9.8P
1034.6	19	10.1P

3712 *U Leonis.*

(Continued from 356.)

Julian	Calendar	Mag.
	1896	
3604.6	Feb. 14	11.6
3660.5	Apr. 10	11.9
3714.6	June 3	11.9
	1897	
3984.5	Feb. 28	11.9
4067.6	May 22	11.6
4096.6	June 20	11.9

3881 *V Hydrae.*

(Cont. from 384. Comp. Stars 384)

Julian	Calendar	Mag.
	1897	
4037.6	Apr. 22	7.5P
4051.5	May 6	7.5P
4053.6	8	6.8P
4064.6	19	6.9P
4067.6	22	7.0P
4070.6	25	7.66
4070.6	25	7.6P
4076.6	31	8.1P

3890 *W Leonis.*

(Continued from 384.)

Julian	Calendar	Mag.
	1897	
3935.6	Jan. 10	11.4 :

3934 *R Crateris.*

Julian	Calendar	Mag.
	1897	
4060.6	May 15	9.2
4061.6	16	9.0
4062.6	17	9.17
4070.6	25	8.98$_2$

— DM. +10°2233.

Julian	Calendar	Mag.
	1897	
4070.6	May 22	11.3
4074.6	29	11.41$_2$
4076.6	31	11.25$_2$
4096.6	June 20	11.1

— DM. +7°2425.

Julian	Calendar	Mag.
	1897	
4067.6	May 22	10.6
4071.6	26	10.79$_2$
4076.6	31	10.57$_2$
4096.6	June 20	10.7

3994 *S Leonis.*

(Continued from 384.)

Julian	Calendar	Mag.
	1897	
4010.6	Mar. 26	11.2
4013.6	29	10.87$_2$
4034.6	Apr. 19	11.09$_2$
4037.5	22	11.29$_2$
4037.6	22	11.2P
4044.7	29	11.6P
4045.6	30	11.4P
4051.6	May 6	11.4P
4053.6	8	11.0]P
4064.6	19	12.0P
4067.6	22	12.2
4070.6	25	12.0:P
4076.6	31	12.0]P

4160 *T Leonis.*

(Continued from 356.)

Julian	Calendar	Mag.
	1896	
3604.6	Feb. 14	11.4
3628.6	Mar. 9	12.00$_2$
3636.5	17	12.43$_2$
3652.6	Apr. 2	11.67$_2$
3658.6	8	12.21$_2$
3687.6	May 7	11.99$_2$

4160 *T Leonis.* — Cont.

Julian	Calendar	Mag.
	1896	
3714.6	June 3	12.38$_2$
	1897	
4014.6	Mar. 30	12.4
4037.5	Apr. 22	11.64$_2$
4044.6	29	11.27$_2$
4045.6	30	11.66$_2$
4050.6	May 5	11.3]
4051.6	6	12.00$_2$
4067.6	22	12.19$_2$
4074.6	29	12.40$_2$
4078.6	June 2	12.27$_2$
4097.6	21	11.90$_2$
4099.6	23	11.56$_2$
4101.6	25	11.49$_2$

4300 *X Virginis.*

(Continued from 356.)

Julian	Calendar	Mag.
	1896	
3636.5	Mar. 17	11.5
3696.6	May 15	11.2
	1897	
4014.6	Mar. 30	11.8
4035.6	Apr. 20	11.2
4067.6	May 22	11.4
4094.6	June 18	11.2

COMPARISON-STARS.

3060 *V Cancri.*

1893-1897

Star	DM.	Mag.	*n*
E	+19°2053	6.70	0*M*
K	+19°2026	8.05	0*M*
N	+19°2047	8.37	4
1*N*	+19°2049	8.38	5
T	+19°2045	9.31	8
Z	+19°2046	10.17	15
1*Z*	+19°2048	10.85	8
g	2*n*6*p* *V*	11.91	5
h	3*n*4*f* *N*	12.19	3
k	5*s* *V*	12.36	6

3184 *T Hydrae.*

1893–1897

Star	DM.	Mag.	*n*
F	−8°2549	7.95	7
1*F*	−8°2504	8.10	10
3*F*	−8°2554	7.57	6
G	−8°2501	8.43	4
K	−8°2509	8.40	7
L	−8°2520	9.06	14
N	−8°2536	8.74	10
T	−8°2534	9.75	8
1*T*	−8°2516	10.38	5
1*W*	−8°2519	10.23	5

3493 *R Leonis.*

1893–1897

Star	DM.	Mag.	*n*
V	+12°2090	5.76	18 *V*
C	+12°2105	6.99	20 *V*
D	+12°2095	6.56	24 *V*
1*I*	+11°2087	7.49	1
W	+12°2091	9.05	2
X	+11°2105	9.85	3
Y	+12°2093	9.58	11
Z	+12°2094	9.81	11
1*Z*	+12°2097	9.69	1
d	1*n*8*f* *V*	11.28	5

4160 *T Leonis.*

1893–1897

Star	DM.	Mag.	*n*
F	+4°2501	7.08	0*M*
Q	+4°2505	8.24	0*M*
U	+4°2504	9.22	0*M*
X	+4°2503	9.53	0
a	2*s*1*f* *Q*	10.80	24
b	5*n* *X*	11.09	18
e	2*s*2*p* *Q*	11.22	26
j	13*s*2*f* *Q*	12.38	14
n	1*n*1*p* *j*	12.92	5
o	6*s*10*f* *Q*	12.98	9

ON THE PROPOSED UNIFICATION OF ASTRONOMICAL CONSTANTS,

BY S. C. CHANDLER.

The contemplated change in the values of the astronomical constants to be used by the various national astronomical ephemerides, beginning with 1901, has naturally excited lively interest, and aroused much discussion which, so far, has not reached public expression. That the matter could not fail to reach the stage of open discussion, at some time or other, is a matter of course. The thanks of astronomers are due to Mr. Boss for his dispassionate, courageous and forcible presentation of the subject in the foregoing article.

But more than this silent approval seems to the writer to be desirable. The situation is one that calls for the individual expressions of opinion by astronomers generally. The discussion is forced upon them both by the importance of the subject, and by the singular features of the method by which the proposed changes have been decided upon. No apology, therefore, is needed from any one for engaging in it; on the contrary, it is an incumbent duty upon all who have an effective word to speak with regard to the proposition, whether of antipathy, apathy, or sympathy.

It would seem to be indisputable that any change of this kind is so important and entails so much inconvenience that it should not be undertaken except after full debate and the general assent of competent opinion. Nor should it be made until the data upon which such opinion must rest have been brought up to within a reasonable time of the date when such change is to go into operation, and are of such a character as to make it likely that the values determined upon will serve for the greater part of the coming century. Without here going into a technical argument, it certainly does not seem that this state of things now exists. Furthermore, there is no good reason whatever why such an alteration should begin with the twentieth century. Surely the making so serious an act contingent on the sentimental association vulgarly attaching to round figures, cannot be gravely considered by scientific men: nor can any adequate argument be advanced for the greater convenience of the date in question, in preference to any other.

It is further to be apprehended, indeed it may be looked upon as reasonably probable, that if the changes are now effected as proposed, they will prove insufficient before a considerable portion of the century shall have elapsed. In such case the consideration of a second change will then have to be entertained. Such a contingency threatens so much inconvenience that it ought, by all prudent foresight, to be avoided.

Therefore, while admitting that an alteration of the constants at present in use will become desirable, and can advantageously be made under proper conditions of knowledge as to what they should be, perhaps within a decade, the writer desires to express a conviction that the adoption of the change proposed, under the present conditions, is premature and unwise. On the other hand he can see no disadvantage in its postponement.

In any event it seems to be desirable that some one, at least, of the National Almanacs should for the present retain the old constants, for the purpose of serving the large body of astronomers the world over who will prefer to use them in their investigations, until a more definitive change can be generally made. In default of this, the suggestion of Mr. Boss at the conclusion of his article, is a practical and feasible one; namely, that some action be taken — as it is pretty sure to be taken — looking to the provision of such facilities by astronomers for themselves, independently of the almanacs, which may then disappear from the astronomers' book-shelves, and be relegated to ship-cabins, where the question of the basis of their construction is a perfectly immaterial one.

OBSERVATIONS OF THE PARTIAL SOLAR ECLIPSE, 1897 JULY 28,

AT THE LEANDER McCORMICK OBSERVATORY,

By Prof. O. Stone and H. R. Morgan. Aperture 3 inches.

Eastern Time (75th meridian)

	h	m	s			
Began,	20	35	14	H.R.M.	Power	50
Ended,	23	10	18	H.R.M.	"	50
"	23	10	7 (perhaps)	O.S.	"	90
"	23	10	12 (certain)	O.S.	"	90

AT MARENGO, ILLINOIS,

By John A. Parkhurst; 6.2-inch reflector reduced to 3.5 inches.

Central Time (90th meridian)

	h	m	s	
First contact,	19	34	49.4	4–5 secs. late
Last contact,	21	45	50.2	good

Clock corrections obtained from transits during the eclipse. Position of Observatory, $\lambda = +5^h\ 54^m\ 25^s.18$, $\varphi = +42°\ 14'\ 51''.5$. Altitude 850 feet.

NEW ASTRONOMICAL WORK.

Catalogue of 14464 *Stars between* 24° 15′ *and* 30° 57′ *of North Declination, for* 1875, *from Observations at the University Observatory, Cambridge, England.* A. Graham.

The great cooperative undertaking of the *Astronomische Gesellschaft*, begun a quarter of a century ago, approaches one step nearer completion by the appearance of Mr. Graham's catalogue, which is the ninth of the series in order of publication. The catalogue proper contains 14441 stars (of which 3 are to be struck out), and an appendix on p. 299 gives 26 others, accidently omitted or insufficiently observed. Each zone-star was observed at least three times when possible, on three wires, and with two microscopes, and each standard star on seven wires, and with four microscopes. The observations were all made substantially by Mr. Graham. The probable error of a single observation, from 945 stars observed seven times or more each, was found to be, in R.A. $\pm 0^s.066$; in Decl. $\pm 0''.51$. A list of 315 stars, in which comparison with other catalogues presents indication of proper motion, is given in the Introduction. In all about 9000 stars have been compared with previous catalogues, and the details of these comparisons, as well as the results of the individual observations of all the stars in the catalogue, are to be given in a larger edition to be subsequently published. C.

CONTENTS.

Note on Prof. Newcomb's Determination of the Constant of Precession and on the Paris Conference of 1896, by Lewis Boss.
Double-Star Measures, by S. B. Soulé.
Double-Star Measures, by Mary S. Wagner.
Notes on Variable Stars, — No. 19, by Henry M. Parkhurst.
On the Proposed Unification of Astronomical Constants, by S. C. Chandler.
Observations of the Partial Solar Eclipse, 1897 June 28.
New Astronomical Work.

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OBSERVATIONS OF COMET 1896 VI (= 1889 V),

MADE AT THE CHAMBERLIN OBSERVATORY, UNIVERSITY PARK, COLORADO,

By HERBERT A. HOWE.

The following observations were made with the 20-inch equatorial and filar micrometer; power, 185. The position of the observatory is given in the *American Ephemeris*, under the heading Denver; log ρ is incorrectly given, as the observatory is 5400 feet above sea-level.

Both $\Delta\alpha$ and $\Delta\delta$ were measured directly, the steady running of the driving clock in all temperatures contributing much to the rapidity and accuracy of the work. On Jan. 4, 1897, the main driving worm was temporarily fast, so that the clock could not turn it, and chronographic observations of $\Delta\alpha$ were made. The telescope was shaken by the wind only about two hours during the entire series of observations. The wind-vibration was sensible in right-ascension only. The comet was connected with faint stars in the field of view, and these were afterward joined to catalogue-stars. The catalogue-positions of a large number of the stars were kindly furnished by Prof. A. S. FLINT of the Washburn Observatory. The apparent differences of right-ascension and declination have been added to the mean places of the catalogue-stars to get the mean places of the comparison-stars. The slight inaccuracies thus introduced have been completely compensated by computing the reductions to apparent place for the catalogue-stars instead of the real comparison-stars.

When several (usually three) consecutive observations are given for the same time, it is to be understood that they were entirely independent of each other. The separate bisections were made in such an order that the mean of the times of those bisections which were made with one star was nearly the same as the mean of the bisection-times for each of the other stars. To assist the orbit-computer these times of observation were made identical, small corrections for the comet's motion being applied to the measurements of $\Delta\alpha$ and $\Delta\delta$. Corrections for refraction were applied throughout.

Miss MARGARET DAVIS, of the Junior Class in the College of Liberal Arts of the University of Denver, computed the probable errors of the observed differences of right-ascension and declination between the comparison-stars and the catalogue-stars with which they were corrected. Apart from unknown instrumental errors these probable errors were respectively $0^s.03$ and $0''.3$. Miss DAVIS also computed the mean places of all the catalogue-stars, the reductions to apparent place, and the parallax factors. She checked some of the rest of the work, and copied the final results for publication.

The use of so many different comparison-stars on a given evening is explained by the observer's hope that his personal errors, and also slight instrumental errors, such as an unknown slant of the wires, would thus be nullified to a certain extent.

The large number of observations seeks justification in the fact that the problem of this comet's motion is a very interesting one, and in the further fact that comparatively few observations seem to have been made elsewhere.

No companion-comets were seen at any time.

1896 Univ. Park M.T.		*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Aug. 31	10 14 29	1	10 , 5	—0 0.15	—3 6.8	22 20 42.62	—19 8 18.6	n9.228	0.868
	10 49 13	2	10 , 5	—0 5.81	+2 17.6	20 41.29	19 8 16.4	n8.997	0.872
	11 12 46	3	10 , 5	—0 11.94	+3 35.8	20 40.45	19 8 17.4	n8.704	0.875
Sept. 1	10 10 2	4	10 , 5	+0 6.85	+4 7.4	20 1.26	19 7 45.5	n9.228	0.867
	10 33 6	5	10 , 5	—0 8.48	+5 11.5	20 0.80	19 7 42.5	n9.089	0.871
	11 10 16	6	10 , 5	—0 9.65	+1 30.3	19 59.39	19 7 44.2	n8.665	0.875
3	10 59 44	7	10 , 5	—0 4.45	—3 37.4	22 18 39.05	—19 6 7.0	n8.690	0.874

1896 Univ. Park M.T.	*	No. Comp.	☄ — *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Sept. 3 11 29 24	8	10 , 5	—0 5.81	—6 33.6	22 18 38.03	—19 6 0.6	8.105	0.875
11 47 31	9	10 , 5	+0 9.43	+4 27.4	18 37.50	19 5 45.6	8.707	0.874
4 11 0 20	10	10 , 5	+0 9.82	—1 58.0	17 58.98	19 5 0.7	n8.581	0.875
11 18 0	11	10 , 5	—0 12.08	—2 18.3	17 58.21	19 4 58.9	n7.073	0.875
11 42 8	12	10 , 5	—0 10.22	—4 53.5	17 57.40	19 4 59.4	8.693	0.874
5 10 44 6	13	10 , 5	+0 15.32	+1 31 5	17 20.08	19 3 46.3	n8.795	0.874
11 0 14	14	10 , 5	—0 0.38	—3 53.4	17 19.70	19 3 42.9	n8.459	0.875
11 20 36	15	10 , 5	—0 13.63	+3 37.8	17 19.42	19 3 42.1	8.141	0.875
7 11 3 21	16	10 , 5	+0 15.36	+0 53.2	16 3.71	19 0 34.3	n7.490	0.875
11 20 39	17	10 , 5	+0 9.33	—0 10.7	16 3.41	19 0 31.2	8.519	0.874
11 40 37	18	10 , 5	—0 7.54	—2 42.0	16 2.98	19 0 31.1	9.062	0.874
11 11 12 59	19	10 , 5	+0 3.84	+0 26.4	13 43.03	18 51 53.1	8.738	0.873
11 30 26	20	10 , 5	+0 5.69	+3 38.2	13 42.84	18 51 57.0	8.958	0.872
11 46 58	21	10 , 5	+0 17.29	+3 29.7	13 42.14	18 51 52.7	9.095	0.870
12 3 0	22	10 , 5	+0 23.03	+1 18.2	13 41.78	18 51 48.9	9.194	0.877
12 11 5 13	23	10 , 5	+0 9.37	+1 14.5	13 11.37	18 49 15.8	8.679	0.873
14 10 36 15	24	10 , 6	+0 14.70	—2 52.2	12 11.54	18 43 25.1	7.763	0.873
10 36 15	25	10 , 6	—0 12.21	—0 40.2	12 11.19	18 43 20.0	7.763	0.873
10 36 15	26	10 , 6	+0 5.41	+1 55.2	12 11.24	18 43 26.2	7.763	0.873
10 36 15	27	10 , 6	+0 2.92	+2 42.2	12 11.21	18 43 21.5	7.763	0.873
15 11 26 28	28	10 , 5	—0 14.66	+0 34.6	11 42.19	18 39 58.3	9.074	0.872
11 26 28	29	10 , 5	+0 1.52	+1 42.6	. . . .	. . . . . .	9.074	0.872
24 11 28 18	30	10 , 6	—0 12.80	+2 54.3	8 40.37	18 1 25.9	9.295	0.859
11 28 17	31	10 , 6	+0 19.46	+5 18.0	8 39.99	18 1 14.5	9.295	0.859
11 28 17	32	10 , 6	+0 14.83	+4 33.5	8 40.11	18 1 15.5	9.295	0.859
11 28 17	33	10 , 6	—0 26.26	+5 12.8	8 40.14	18 1 23.6	9.295	0.859
28 9 39 21	34	10 , 5	—0 24.69	+1 47.2	8 5.79	17 39 38.3	8.017	0.868
9 39 21	35	10 , 5	—0 4.98	—1 22.0	8 5.65	17 39 45.7	8.017	0.868
9 39 21	36	10 , 5	+0 5.35	+5 17.8	8 6.50	17 39 41.9	8.017	0.868
9 39 21	37	10 , 5	+0 16.82	+4 36.1	8 6.06	17 39 45.7	8.017	0.868
9 39 21	38	10 , 5	+0 22.26	—0 35.8	8 5.50	17 39 40.8	8.017	0.868
9 39 21	39	10 , 5	+0 23.97	+3 26.5	8 5.46	17 39 41.8	8.017	0.868
9 39 21	40	10 , 5	+0 10.65	+0 51.7	8 6 33	17 39 43.2	8.017	0.868
9 39 21	41	10 , 5	+0 12.79	+1 59.1	8 6.27	17 39 44.1	8.017	0.868
29 11 14 42	42	10 , 6	—0 3.15	—2 28.5	8 1.45	17 33 25.9	9.320	0.855
11 14 42	43	10 , 6	—0 11.21	—5 29.3	8 1.34	17 33 29.4	9.320	0.855
11 14 42	44	10 , 6	—0 13.82	—5 8.5	8 1.50	17 33 28.9	9.320	0.855
30 10 13 58	45	10 , 5	+0 2.59	—1 2.0	7 59.67	17 27 32.6	8.981	0.865
Oct. 1 10 33 6	46	10 , 6	—0 8.70	—3 31.2	7 59.41	17 21 9.4	9.159	0.861
10 33 6	47	10 , 6	—0 6.04	—4 30.9	7 59.52	17 21 9.0	9.159	0.861
10 33 6	48	10 , 6	+0 3.03	—0 26.3	7 59.47	17 21 3.6	9.159	0.861
10 33 6	49	10 , 6	+0 13.05	—0 19.4	7 59.40	17 21 8.0	9.159	0.861
2 10 21 37	50	10 , 6	—0 1.99	+0 53.9	8 1.05	17 14 33.2	9.111	0.862
10 21 37	51	10 , 6	—0 15.87	+0 20.6	8 1.09	17 14 32.9	9.111	0.862
3 9 52 7	52	10 , 6	—0 16.04	—1 55.6	8 4.43	17 8 5.1	8.888	0.864
9 52 7	53	10 , 6	—0 12.88	—5 42.5	8 4.79	17 8 8.6	8.888	0.864
9 52 7	54	10 , 6	+0 2.94	—5 44.9	8 4.90	17 8 9.6	8.888	0.864
10 10 10 29	55	10 , 6	—0 9.58	+2 34.0	9 26.45	16 16 31.9	9.218	0.854
10 10 29	56	10 , 6	—0 5.53	—0 22 6	9 26.39	16 16 30.5	9.218	0.854
10 10 29	57	10 , 6	+0 6.46	—0 48.9	9 26.67	16 16 39.1	9.218	0.854
10 10 29	58	10 , 6	+0 15.71	—3 55.2	9 26.52	16 16 37.0	9.218	0.854
10 10 29	59	10 , 6	+0 17.48	—1 29.7	9 26.52	16 16 35.4	9.218	0.854
10 10 29	60	10 , 6	+0 18.13	+1 18.9	9 26.41	16 16 34.6	9.218	0.854
10 10 29	61	10 , 6	+0 21.89	+2 31.4	9 26.35	16 16 36.2	9.218	0.854
24 7 15 18	62	10 , 6	+0 17.24	+3 27.3	16 47.34	14 13 15.1	n8.965	0.848
7 15 18	63	10 , 6	+0 3.40	—3 1.9	16 47.48	14 13 23.9	n8.965	0.848
7 15 18	64	10 , 6	+0 0.45	—2 36.4	16 47.68	14 13 26.4	n8.965	0.848
27 7 32 53	65	5 , 0	—0 5.20	. . . .	19 8.04	. . . . . .	n8.575	. . .
7 37 44	66	5 , 0	+0 2.04	. . . .	19 8.36	. . . . . .	n8.443	. . .
7 42 25	67	5 , 0	+0 5.13	. . . .	19 9.01	. . . . . .	n8.260	. . .
7 47 11	68	5 , 0	+0 10.71	. . . .	19 9.33	. . . . . .	n7.928	. . .
7 57 9	66	0 , 3	. . . .	+2 20.8	. . . .	13 43 12.3	. . .	0.848
8 4 1	65	0 , 6	. . . .	+1 3.2	. . . .	13 43 5.7	. . .	0.847
8 5 38	67	0 , 6	. . . .	—0 44.7	. . . .	13 43 8.1	. . .	0.847
8 5 39	68	0 , 6	. . . .	—0 8.1	. . .	13 43 10.3	. . .	0.847
29 7 16 15	69	10 , 6	+0 14.44	+0 28.4	20 49.62	13 23 6.2	n8.768	0.845
7 16 15	70	10 , 6	+0 9.99	—3 37.8	20 50.28	13 23 7.0	n8.768	0.845
7 16 15	71	10 , 6	+0 7.12	+3 55.6	20 49.53	13 22 57.2	n8.768	0.845
7 16 15	72	10 , 6	—0 2.20	—4 3.0	20 49.73	13 23 4.3	n8.768	0.845
8 31 14	73	11 , 6	—0 0.53	+7 48.0	20 51.88	13 22 9.6	8.968	0.844
8 31 14	74	10 , 6	—0 18.16	+4 50.9	20 51.86	13 22 42.8	8.968	0.844
8 31 14	75	10 , 6	—0 25.31	+1 29.4	20 52.06	13 22 37.0	8.968	0 844
8 31 14	76	10 , 6	—0 28.42	+1 23.6	20 51.86	13 22 45.7	8.968	0.844
30 6 40 8	77	5 , 0	+0 21.19	. . . .	21 41.26	. . . . . .	n9.095	. . .
6 44 38	78	5 , 0	+0 17.43	. . . .	21 41.21	. . . . . .	n9.063	. . .
6 50 58	79	5 , 0	+0 3.93	. . . .	21 41.70	. . . . . .	n9.013	. . .
Nov. 5 9 34 3	80	10 , 6	+0 5.89	+7 41.7	22 27 38.29	—12 6 56.9	9.395	0.824

1896 Univ. Park M.T.		*	No. Comp.	☄ – *		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Nov. 5	9 34 3	81	10 , 6	−0 10.30	+7 30.8	22 27 38.22	−12 6 57.6	9.395	0 824
	9 34 3	82	10 , 6	−0 11.95	+5 37.2	27 38.44	12 6 53.5	9.395	0.824
	9 34 3	83	10 , 6	−0 15.69	+5 42.5	27 38.38	12 6 55.6	9.395	0.824
6	7 9 32	84	10 , 6	+0 20.92	−0 4.7	28 36.07	11 56 55.3	n8.382	0.837
	7 9 32	85	10 , 6	−0 16.20	−0 33.1	28 36.07	11 56 55.0	n8.382	0.837
	7 9 32	86	10 , 6	−0 20.37	+2 31.8	28 35.58	11 56 59.5	n8.382	0.837
	8 16 12	87	10 , 6	−0 19.80	+3 56.0	28 38.94	11 56 23.5	9.040	0.834
	8 16 12	88	10 , 6	−0 22.51	+1 46.4	28 38.92	11 56 23.9	9.040	0.834
	8 16 12	89	10 , 6	−0 22.62	+6 22.2	28 38.57	11 56 24.1	9.040	0.834
	8 16 12	90	10 , 6	−0 31.93	−1 44.9	28 39.07	11 56 25.7	9.040	0.834
7	8 50 37	91	10 , 6	+0 28.78	−1 34.3	29 45.09	11 44 59.0	9.257	0.829
	8 50 37	92	10 , 6	+0 24.14	−1 46.5	29 45.04	11 45 1.1	9.257	0.829
	8 50 37	93	10 , 6	+0 20.76	+0 26.7	29 44.99	11 44 57.2	9.257	0.829
	9 53 16	94	10 , 6	+0 8.05	+5 59.0	29 47.79	11 44 23.4	9.461	0.816
	9 53 16	95	10 , 6	+0 7.82	+1 41.5	29 47.89	11 44 23.2	9.461	0.816
	9 53 16	96	10 , 6	+0 3.49	+3 50.9	29 47.24	11 44 26.6	9.461	0.816
10	7 24 44	97	10 , 6	+0 17.26	+2 1.2	33 3.49	11 11 20.5	8.468	0.832
	7 24 44	98	10 , 6	+0 8.10	−1 13.1	33 3.78	11 11 21.5	8.468	0.832
	7 24 44	99	10 , 6	+0 0.45	−4 42.4	33 3.22	11 11 23.6	8.468	0.832
	7 24 44	100	10 , 6	−0 5.27	−3 56.2	33 3.54	11 11 22.1	8.468	0.832
23	7 45 17	101	10 , 6	+0 23.95	+3 10.2	49 42.55	8 34 8.3	9.137	0.812
	7 45 17	102	10 , 6	+0 15.55	−0 39.1	49 42.81	8 34 7.4	9.137	0.812
28	7 21 10	103	10 , 6	+0 24.70	+0 8.1	56 49.84	7 30 37.5	9.059	0.806
	7 21 10	104	10 , 6	+0 14.84	+2 12.9	56 49.93	7 30 43.4	9.059	0.806
	7 21 10	105	10 , 6	+0 3.87	+6 45.3	56 49.84	7 30 40.8	9.059	0.806
	7 21 10	106	10 , 6	−0 6.42	+7 5.0	56 49.90	7 30 39.2	9 059	0.806
	9 11 48	107	10 , 6	−0 26.23	−1 16.6	56 56.11	7 29 42.2	9.487	0.792
	9 11 48	108	10 , 6	−0 27.93	−0 34.1	56 56.35	7 29 40.8	9.487	0.792
30	7 2 52	109	10 , 6	+0 18.42	+5 49.0	59 46.49	7 4 53.1	8.947	0.804
	7 2 52	110	10 , 6	+0 14.68	−3 58.7	59 46.31	7 4 55.4	8 947	0.804
	7 2 52	111	10 , 6	+0 4.96	−5 45.3	59 46.30	7 4 51.4	8.947	0.804
	7 36 25	112	5 , 0	−0 5.91	. . . .	59 48.16	. . . . . .	9.184	. . .
	7 42 2	113	5 , 0	−0 12.81	. . . .	59 48.45	. . . . . .	9.213	. . .
	7 47 49	114	5 , 0	−0 15.76	. . .	22 59 48.83	. . . . . .	9.241	. . .
	8 1 56	112	0 , 4	. . . .	+2 43.0	. . . .	7 4 14.6	. . .	0.799
	8 6 13	113	0 , 3	. . . .	+5 26.1	. . . .	7 4 16.5	. . .	0.799
	8 9 18	114	0 , 1	. . . .	−0 46.9	. . . .	7 4 11.3	. . .	0.798
Dec. 3	6 47 39	115	10 , 6	+0 23.36	+0 33.6	23 4 16.99	6 25 38.3	8.863	0.800
	6 47 39	116	10 , 6	+0 6.29	−6 6.0	4 17.17	6 25 51.8	8.863	0.800
	6 47 39	117	10 , 6	+0 2.67	+7 24.1	4 16.88	6 25 35.7	8.863	0.800
	7 39 14	118	10 , 6	+0 2.56	+2 3.6	4 19.93	6 25 13.9	9.234	0.796
	7 39 14	119	10 , 6	+0 0.39	+1 54.9	4 19.17	6 25 10.7	9.234	0.796
	7 39 14	120	10 , 6	−0 1.05	−0 20.1	4 20.37	6 25 11.3	9.234	0.796
	8 35 3	121	10 , 6	−0 12.72	−0 31.8	4 24.46	6 24 43.7	9.428	0.790
	8 35 3	122	10 , 6	−0 14 39	−0 41.6	4 24.73	6 24 43,1	9.428	0.790
	8 35 3	123	10 , 6	−0 16.38	+0 4.5	4 23.59	6 24 48.0	9.428	0.790
	9 15 6	124	10 , 6	−0 21.10	−2 3.7	4 26.26	6 24 27.6	9.516	0.784
5	6 57 44	125	10 , 6	+0 8.94	+2 49.0	7 23.21	5 59 4.1	9.008	0.796
	6 57 44	126	10 , 6	+0 7.25	+0 9.1	7 23.09	5 59 10.1	9.008	0.796
	6 57 44	127	10 , 6	+0 7.59	−5 18.1	7 22.86	5 59 19.7	9.008	0.796
	7 43 29	128	10 , 6	+0 0.89	+0 51.2	7 25.95	5 58 37.3	9.274	0.793
	7 43 29	129	10 , 6	−0 11.20	−1 57.3	7 26.02	5 58 40.2	9.274	0.793
	7 43 29	130	10 , 6	−0 11.50	+3 9.8	7 25.65	5 58 39.1	9.274	0.793
	8 31 39	131	10 , 6	−0 10.60	−3 4.0	7 29.05	5 58 18.3	9.432	0.788
	8 31 39	132	10 , 6	−0 12.50	+6 29.7	7 28.81	5 58 8.2	9.432	0.788
	8 31 39	133	10 , 6	−0 15.51	+6 23.1	7 28.75	5 58 10.7	9.432	0.788
7	8 26 19	134	10 , 6	+0 18.49	+3 10.5	10 36.63	5 31 32.0	9.430	0.785
	8 26 19	135	10 , 6	+0 18.38	+3 47.3	10 37.34	5 31 31.0	9.430	0.785
	8 26 19	136	10 , 6	+0 6.71	+6 40.5	10 36.86	5 31 31.4	9.430	0.785
	8 26 19	137	10 , 6	−0 1.63	+4 15.4	10 36.67	5 31 33.9	9.430	0.785
22	6 52 15	138	10 , 6	−0 8.30	−1 51.9	35 19.00	2 6 32.2	9.217	0.765
	6 52 15	139	10 , 6	−0 14 53	+1 8.3	35 19.23	2 6 49.0	9.217	0.765
	6 52 15	140	10 , 6	−0 21.94	−3 51.2	35 19.10	2 6 34.5	9.217	0.765
	7 26 15	141	5 , 4	+0 7.36	+1 53.9	35 21.80	2 6 12.5	9.352	0.764
	7 33 31	142	5 , 8	+0 5.27	+1 54.5	35 22.44	2 6 11.7	9.376	0.763
23	6 47 16	143	10 , 6	+0 5.58	+0 49.0	37 2.20	1 52 44.8	9.203	0.763
	6 47 16	144	10 , 6	−0 5.90	+4 5.3	37 2.33	1 52 34.2	9.203	0.763
	6 47 16	145	10 , 6	−0 16.69	+2 42.9	37 2.08	1 52 39.2	9.203	0.763
	7 46 24	146	10 , 6	+0 3.01	+2 0.3	37 6.32	1 52 6.9	9.419	0.761
	7 46 24	147	10 , 6	−0 26.59	+1 14.8	37 6.39	1 52 10.4	9.419	0.761
24	7 42 14	148	10 , 6	+0 15.92	−0 18.4	38 49.94	1 38 12.6	9.414	0.759
	7 42 14	149	10 , 6	+0 14.47	+2 56.2	38 49.65	1 38 13.6	9.414	0.759
	7 42 14	150	10 , 6	−0 17.60	+2 41.1	38 50 44	1 38 10.9	9.414	0.759
25	7 14 31	151	10 , 6	+0 14 01	+6 3.0	40 32.28	1 24 23.4	9.335	0.758
	7 14 31	152	10 , 6	+0 8.03	+4 18.7	40 32.21	1 24 27.3	9.335	0.758
	7 14 31	153	10 , 6	+0 3.19	−4 31.7	40 32.38	1 24 28.0	9.335	0.758
	8 4 2	154	10 , 6	+0 0.35	−1 17.5	23 40 35.95	− 1 23 53.7	9.472	0.757

1896 7 Univ. Park M.T.		*	No. Comp.	☄ − *		☄'s apparent		log pΔ	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	″	h m s	° ′ ″		
Dec. 25	8 4 2	155	10 , 6	−0 23.34	−1 56.9	23 40 36.04	−1 23 56.8	9.472	0.757
28	6 47 30	156	5 , 0	+0 9.46	. . . .	45 15.97	. . . . .	9.255	. . .
	6 52 14	157	5 , 0	+0 6.69	. . .	45 46.61	. . . . .	9.275	. . .
	6 56 36	158	5 , 0	−0 5.63	. . . .	45 15.93	. . . . .	9.293	. . .
	7 10 16	158	0 , 6	. . . .	+5 41.9	. . . .	0 42 1.0	. . .	0.753
	7 10 58	157	0 , 6	. . . .	+4 21.9	. . . .	0 42 3.8	. . .	0.753
	7 15 8	156	0 , 6	. . . .	+1 42.0	. . . .	−0 42 7.1	. . .	0.753
'97 Jan. 4	7 30 0	159	10 , 6	+0 29.18	−0 28 1	58 19.74	+0 57 0 5	9.443	0.740
	7 46 47	160	21 , 6	−0 1.83	−3 39.0	58 21.00	0 57 9.3	9.482	0.741
	7 50 59	161	24 , 6	−0 8.69	−0 21.2	58 21.87	0 57 11.6	9.490	0.741
	7 50 59	162	24 , 6	−0 15.19	−3 59.4	58 21.82	0 57 8.8	9.490	0.741
	8 34 31	163	24 , 6	−0 25 31	+0 48.0	58 24.80	0 57 39.3	9.564	0.742
	8 40 58	164	23 , 6	−0 28.98	−1 30.9	23 58 25.16	0 57 44.4	9.572	0.742
5	7 34 42	165	10 , 6	+0 21.92	+1 45.7	0 0 8.99	1 11 13.3	9.457	0.739
	7 34 42	166	10 , 6	+0 10.90	−1 35.1	0 8.82	1 11 13.0	9.457	0.739
	7 34 42	167	10 , 6	+0 10.70	+1 57.2	0 9.09	1 11 16.1	9.457	0.739
22	7 41 56	168	10 , 6	−0 12.71	−3 13.5	31 43.65	5 12 0 0	9.543	0.714
	7 41 56	169	10 , 6	−0 15.14	+1 58.6	31 43.70	5 12 6.2	9.543	0.714
	7 41 56	170	10 , 6	−0 18.89	+3 5.8	31 43.91	5 12 8.3	9.543	0.711
	7 33 7	171	10 , 6	+0 5.06	−2 20.3	39 19.78	6 8 5.0	9.543	0.706
	7 33 7	172	10 , 6	+0 2.20	+1 27.2	39 19.62	6 8 7.8	9.513	0.706
	7 33 7	173	10 , 6	−0 3.90	−1 46.5	0 39 20.15	+6 8 8.4	9.543	0.706

Mean Places, for beginning of year, of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority		
	h m s	s	° ′ ″	″		m s	′ ″
1	22 20 38.39	+4.38	−19 5 31.5	+19.7	Cincinnati 1829		
2	20 42.72	4.38	19 10 53.7	19.7	Cincinnati 1829	+ 0 4.33	− 5 22.2
3	20 48.01	4.38	19 12 12.9	19.7	Lick Obs., *A.J.* 387		
4	19 50.02	4.39	19 12 12.5	19.6	Lick Obs., *A.J.* 387		
5	20 4.89	4.39	19 13 14.0	20.0	Cincinnati 1836	− 4 7.89	+12 4.8
6	20 4.66	4.38	19 9 34.7	20.2	Munich (1) 31091	− 5 25.86	+ 6 49.4
7	18 39.09	4.41	19 2 49.3	19.7	Lick Obs. *A.J.* 387	− 1 59.23	+ 2 43.3
8	18 39.43	4.41	18 59 46.7	19.7	Yarnall 10125	− 1 46.65	− 6 48.6
9	18 23.66	4.41	19 10 32.9	19.9	Cincinnati Z. 3785	− 4 47.67	+ 4 38.1
10	17 44.75	4.41	19 3 21.9	19.2	Cincinnati 1821	+ 2 0.81	− 1 35.4
11	18 5.88	4.41	19 3 0.7	20.1	Munich (1) 31091	− 7 24.64	− 0 15.4
12	18 3.21	4.41	19 0 25.9	20.0	Munich 31049	− 6 22.60	− 3 59.2
13	17 0.34	4.42	19 5 36.9	19.1	Cincinnati 1821	+ 1 16.40	− 3 50.4
14	17 15.67	4.41	19 0 9.4	19.9	Munich (1) 31049	− 7 10.14	− 3 42.7
15	17 28.62	4.43	19 7 38.6	18.7	Cincinnati 1811	+ 5 49.80	+11 21.7
16	15 43.94	4.41	19 1 46.5	19.0	Cincinnati 1821		
17	15 49.66	4.42	19 0 39.1	18.6	Cincinnati 1811	+ 1 10.84	+18 21.2
18	16 6.11	4.41	18 58 9 2	20.1	Cincinnati 1842	−12 26.97	+15 12.7
19	13 34.80	4.39	18 52 38.8	19.3	Munich (1) 30923	− 7 3.90	−20 31.5
20	13 32.74	4.41	18 55 53.4	18.2	Cincinnati 1809	+ 4 29.55	+16 38.6
21	13 20.44	4.41	18 55 40.6	18.2	Cincinnati 1809	+ 4 17.25	+16 51.4
22	13 14.36	4.39	18 53 26.4	19.3	Munich (1) 30923	− 7 24.34	−21 19.1
23	12 57.60	4.40	18 50 47.9	17.6	Yarnall 9970	+ 9 40.82	+10 54.6
24	11 52.44	4.40	18 40 51.4	18.5	Arg. (W) 22050		
25	12 18.99	4.41	18 42 57.4	17.6	Yarnall 9970	+ 9 2.21	+18 45.1
26	12 1.42	4.41	18 45 39.0	17.6	Yarnall 9973	+ 8 37.61	+13 58.2
27	12 3.88	4.41	18 46 21.3	17.6	Yarnall 9970	+ 8 47.10	+15 21.2
28	11 52.44	4.41	18 40 51.4	18.5	Arg. (W) 22050		
29	11 36.	4.41	18 42 –	18.5	Anonymous	+ 4 52.43	+ 3 44.4
30	8 48.83	4 34	18 4 37.6	17.4	Yarnall 10006	+ 1 56.38	+27 48.6
31	8 16.18	4.35	18 6 50.1	17.6	Munich (1) 30528	− 1 45.88	+32 31.8
32	8 20.93	4.35	18 6 6.6	17.6	Munich (1) 30528	− 1 41.13	+33 15.3
33	9 2.06	4.34	18 6 53.7	17.3	Yarnall 10001	+ 2 25 10	+31 35.6
34	8 26.14	4.34	17 41 43.2	17.7	Munich (1) 30622	− 3 59.25	+48 22.2
35	8 6.31	4.32	17 38 41.6	17.9	Munich (1) 30692	− 6 11.73	+20 27.7
36	7 56.82	4.33	17 45 16.9	17.2	Yarnall 10006	+ 1 4.37	+47 9.3
37	7 44.93	4.31	17 44 39.3	17.5	Arg. (W) 17276		
38	7 38.93	4.31	17 39 21.9	16.9	Yarnall 9966	+ 5 6.62	+41 3.6
39	7 37.18	4.31	17 43 25.2	16.9	Yarnall 9966	+ 5 4.87	+37 0.3
40	7 51.36	4.32	17 40 52.5	17.6	Arg. (W) 17302	− 2 39.48	+21 2.4
41	7 49.16	4.32	17 41 58.8	17.6	Arg. (W) 17302	− 2 41.68	+19 56.1
42	8 0.29	4.31	17 31 15.4	18.0	Arg. G.C. 30413	− 2 37.12	+27 53.9
43	8 8.24	4.31	17 28 18.2	18.1	Radcliffe (3) 5996	− 5 47.61	−14 54.4
44	8 11.01	4.31	17 28 38.5	18.1	Radcliffe (3) 5996	− 5 44.84	−15 14.7
45	7 52.81	4.27	17 26 48.0	17.4	Arg. G.C. 30413	− 2 44.60	+16 35.0
46	22 8 3.83	+4.28	−17 17 55.6	+17.4	Radcliffe (3) 9931	+ 0 35.92	− 9 47.1

*	α			Red. to app. place	δ			Red. to app. place	Authority				
	h	m	s	s	°	′	″	″		m	s	′	″
47	22	8	1.28	+4.28	−17	16	55.5	+17.4	Radcliffe (3) 9931	+0	33.37	−8	47.0
48		7	52 14	4.30	17	20	54.6	17.3	Arg. (W) 17276	+0	7.21	+23	44.7
49		7	42.05	4.30	17	21	6.7	18.1	Arg. (W) 17344	−7	8.01	−15	2.2
50		7	58.75	4.29	17	15	44.5	17.4	Arg. (W) 17292	−1	20.40	+23	49 0
51		8	12.67	4.29	17	15	10.9	17.4	Arg. (W) 17292	−1	6.48	+24	22.6
52		8	16.19	4.28	17	6	27.4	17.9	Arg. (W) 17341	−6	33.87	−0	22.9
53		8	13.38	4.29	17	2	44.1	18 0	Arg. (W) 17361	−8	29.03	+9	51.8
54		7	57.67	4.29	17	2	42.7	18.0	Arg. (W) 17361	−8	44.74	+9	53.2
55		9	31 86	4.17	16	19	22.9	17.0	Arg. (W) 17275	+1	51.57	+8	45.5
56		9	27.75	4.17	16	16	24.9	17.0	Arg. (W) 17275	+1	47.46	+11	43.5
57		9	16.03	4.18	16	16	7.9	17.7	Rümker 10049	−3	37.95	−5	25.7
58		9	6.63	4.18	16	12	59.1	17.3	Radcliffe (3) 5992	−2	42.62	+16	56.7
59		9	4.86	4.18	16	15	23.0	17.3	Radcliffe (3) 5992	−2	44.39	+11	32.8
60		9	4.11	4.17	16	18	11.0	17.5	Radcliffe (3) 5981	+0	3.82	+1	14.1
61		9	0.29	4.17	16	19	25.1	17.5	Radcliffe (3) 5981				
62		16	26.06	4.04	14	17	0.3	17.9	Arg. (W) 17421	−6	41.11	+2	50.7
63		16	40.08	4.00	14	10	39.7	17.7	Radcliffe (3) 6015	−2	12.66	−7	16.3
64		16	43.23	4.00	14	11	7.7	17.7	Radcliffe (3) 6015	−2	9.51	−7	44.3
65		19	9.27	3.97	13	44	26.6	17.7	W. Bessel 352				
66		19	2.37	3.95	13	45	50.3	17.2	Radcliffe (3) 5995	+5	36.65	+3	41.5
67		18	59.91	3.97	13	42	41.1	17.7	W. Bessel 343				
68		18	54.65	3.97	13	43	19.9	17.7	W. Bessel 341				
69		20	31.21	3.97	13	23	52.6	18 0	Radcliffe (3) 6034	−3	56.56	+2	58.7
70		20	36.34	3.95	13	19	47.0	17.8	W. Bessel 388				
71		20	38.45	3.96	13	27	10.6	17.8	Arg. (W) 17414	−1	24.02	+8	8.7
72		20	47.96	3.97	13	19	19.3	18.0	Radcliffe (3) 6034	−3	39.81	+7	32.0
73		20	48.45	3.96	13	30	15.4	17.8	Arg. (W) 17414	−1	14.02	+5	3.9
74		21	6.07	3.95	13	27	51.4	17.7	Yarnall 10112	+1	31.93	+3	56.5
75		21	13.42	3.95	13	24	24.1	17.7	Yarnall 10112	+1	39.28	+7	23.8
76		21	16.32	3.96	13	24	27.1	17.8	*Arg. (W) 17414	−0	46.15	. .	. .
77		21	16.17	3.90	. .	. .	. .	. .	Radcliffe (3) 5987	+10	2.32	. .	. .
78		21	19.88	3.90	. .	. .	. .	. .	Radcliffe (3) 5987	+10	6.03	. .	. .
79		21	33.86	3.91	. .	. .	. .	. .	W. Bessel 273	+5	23.82	. .	. .
80		27	28.53	3.87	12	14	57.0	18.4	Radcliffe (3) 6060	−4	6.59	+1	14.0
81		27	44.65	3.87	12	14	46.8	18.4	Radcliffe (3) 6060	−3	50.47	+1	24.2
82		27	46.56	3.83	12	12	48.4	17.7	Munich (1) 30993	+5	9.92	+12	27.4
83		27	50.24	3.83	12	12	55.8	17.7	Munich (1) 30993	+5	13.60	+12	20.0
84		28	11.28	3.87	11	57	9.2	18.6	Munich (1) 31378	−6	39.66	+11	39.4
85		28	48.42	3.85	11	56	40.2	18.3	W. Bessel 588	−1	39.02	+11	39.7
86		28	52.13	3.82	11	59	49.1	17.8	Munich (1) 31011	+5	31.49	+13	27.2
87		28	54.92	3.82	12	0	37.3	17.8	Munich (1) 31045	+4	40.56	+14	9.6
88		28	57.60	3.83	11	58	28.2	17.9	Munich (1) 31378	−5	53.34	+10	20.4
89		28	57.36	3.83	12	3	4.1	17.8	Munich (1) 31045	+4	43.00	+11	42.8
90		29	7.18	3.82	11	54	58.7	17.9	†W. Bessel 459	+4	56.40	+8	17.2
91		29	12.49	3.82	11	43	42.9	18.2	Radcliffe (3) 6043	+3	2 00	−17	24.7
92		29	17.08	3.82	11	44	32.8	18.2	Radcliffe (3) 6043	+3	6.59	−18	14.6
93		29	20.41	3.82	11	45	42.2	18.3	Brussels 10089	+2	23.99	−17	11.3
94		29	35.94	3.80	11	50	40.2	17.8	Radcliffe (3) 6026	+8	25.81	−5	16.4
95		29	36.25	3.82	11	46	23.0	18.3	Brussels 10089	+2	39.83	−17	52.1
96		29	39.94	3.81	11	48	35.5	18.0	W. Bessel 468	+5	7.82	−4	26.7
97		32	42.44	3.79	11	13	39.9	18.2	Radcliffe (3) 6040	+7	33.87	−1	3.9
98		32	51.89	3.79	11	10	26.6	18.2	Radcliffe (3) 6040	+7	43.32	+2	9.4
99		32	58.98	3.79	11	6	59.4	18.2	Brussels 10070	+7	36.84	+2	31.0
100		33	5.02	3.79	11	7	44.1	18.2	Brussels 10076	+7	29.58	+0	35.7
101		49	14.94	3.66	8	37	37.1	18.6	Radcliffe (3) 6103	+6	18.68	+2	3.0
102		49	23.57	3.69	8	33	48.1	19.8	Schjellerup 9392				
103		56	21.49	3.65	7	31	5.7	20.1	Yarnall 10412				
104		56	31.44	3.65	7	33	16.3	20.0	Yarnall 10404	+1	20.40	+4	22.6
105		56	42.32	3.65	7	37	46.2	20.1	Yarnall 10412	+0	20.83	−6	40.5
106		56	52.64	3.68	7	38	4.5	20.3	Yarnall 10450	−3	11.19	+5	22.6
107		57	18.69	3.65	7	28	45.7	20.1	Radcliffe (3) 6160	+1	19.40	+8	23.6
108		57	20.63	3.65	7	29	26.8	20.1	Radcliffe (3) 6160	+1	21.34	+7	42.5
109		59	24 44	3.63	7	11	2.3	20.2	Munich (1) 31979				
110		59	28.01	3.62	7	1	16.9	20.2	Radcliffe (3) 6166	+2	19.43	+6	38.7
111		59	37.72	3.62	6	59	26.3	20.2	Radcliffe (3) 6166	+2	29 14	+8	29.3
112		59	50.44	3.63	7	7	17.8	20.2	Yarnall 10438	+0	51.21	+7	36.6
113	22	59	57.63	3.63	7	10	2.8	20.2	Yarnall 10438	+0	58 40	+4	51.6
114	23	0	0.95	3.64	7	3	44.7	20.3	Munich (1) 31991	+0	3.38	+9	37.1
115		3	49.99	3.64	6	26	32.7	20.8	Radcliffe (3) 6210	−5	6 01	+10	0.4
116		4	7.30	3.58	6	20	6.1	20.3	Munich (1) 31930	+6	53.13	−2	40 9
117		4	10.57	3.64	6	33	20.6	20.8	Brussels 10416	−5	1.36	+7	37.5
118		4	13.78	3.59	6	27	37.7	20.2	Munich (1) 31969	+5	8.47	+16	47.5
119		4	15.14	3.64	6	27	26.4	20.8	Radcliffe (3) 6210	−4	40.86	+9	6.7
120		4	17.85	3 57	6	25	11.4	20.2	Yarnall 10414	+7	47.40	+6	13.8
121		4	33.56	3.62	6	24	32.5	20.6	Radcliffe (3) 6198	−0	42.95	+6	55.5
122		4	35.50	3.62	6	24	22.1	20.6	Radcliffe (3) 6198	−0	41.01	+7	5.9
123	23	4	36.34	+3.63	−6	25	13.3	+20 8	Munich (1) 32154	−3	24.37	−0	10.6

Also, *W. Bessel 388 −4′ 40″.1   Also, † W. Bessel 463 +4ᵐ 51ˢ.35 +8′ 17″.6.

*	α			Red. to app. place	δ			Red. to app. place	Authority				
	h	m	s	s	°	′	″	″		m	s	′	″
124	23	4	43.78	+3.58	— 6	22	44 3	+20.4	Munich (1) 31963	+5	54.51	— 2	36.8
125		7	10.62	3.65	6	2	14.2	21.1	Brussels 10450	—6	11.06	+ 9	34.0
126		7	12.27	3.57	5	59	39.6	20.4	Yarnall 10441	+7	57.43	+ 4	5.0
127		7	11.68	3.59	5	54	22.3	20.7	Munich (1) 32067	+3	33.49	+ 0	1.1
128		7	21.42	3.64	5	59	49.6	21.1	* Yarnall 10553	—5	11.78	. .	. .
129		7	33.56	3.66	5	57	4.1	21.2	Schjellerup 9590	—5	26.82	+ 0	53.5
130		7	33 51	3.64	6	2	10.0	21.1	Yarnall 10551	—4	49.77	+ 5	54.4
131		7	36.03	3.62	5	55	35.3	21.0	Brussels 10418	—1	55.13	+ 0	46.1
132		7	37.72	3.59	6	4	58.4	20.5	Schjellerup 9505–6	+5	10.16	+10	37.0
133		7	40.63	3.63	6	4	54.7	20.9	Yarnall 10528	—2	37.65	+10	53.8
134		10	14.49	3.65	5	35	3 9	21.4	Brussels 10485	—7	12.61	+ 1	21.1
135		10	15.37	3.59	5	35	39.2	20.9	Yarnall 10493	+4	20.78	+ 4	8.9
136		10	26.51	3.64	5	38	33.1	21.2	Radcliffe (3) 6237	—3	33.77	+ 2	59.2
137		10	34.66	3.64	5	36	10.5	21.2	Radcliffe (3) 6237	—3	25.62	+ 5	21.8
138		35	23.77	3.53	2	5	2.6	22.3	Munich (1) 32605	+3	27.14	+ 0	29.2
139		35	30.22	3.54	2	8	19.6	22.3	Munich (1) 32614	+3	0.39	— 3	24.8
140		35	37.49	3.55	2	3	5.8	22.5	Yarnall 10736	+0	27.05	— 6	54.0
141		35	10.85	3.59	2	8	29.1	22.7	Yarnall 10775	—6	51.66	— 3	21.5
142		35	13.58	3.59	2	8	28.9	22.7	Yarnall 10775	—6	48.93	— 3	21.3
143		36	53.12	3.50	1	53	56.0	22.2	Yarnall 10694	+8	5.13	— 4	37.8
144		37	4.70	3.53	1	57	1.8	22.3	Munich (1) 32621	+4	18.11	— 2	27.0
145		37	15.25	3.52	1	55	44.5	22.4	Yarnall 10715	+5	24.84	—14	18.5
146		36	59.81	3.50	1	54	29.4	22.2	Yarnall 10694	+8	11.82	— 5	11.2
147		37	29.46	3.52	1	53	47.6	22.4	Yarnall 10715	+5	39.05	—12	21.6
148		38	30.51	3.51	1	38	16.5	22.3	Yarnall 10716	+6	34.49	— 0	45.0
149		38	31.67	3.51	1	41	32.2	22.4	Yarnall 10728	+4	24.54	— 8	18.2
150		39	4.51	3.57	1	41	14.5	22.5	Munich (1) 32678	+2	28.44	— 0	53.2
151		40	14.78	3.49	1	30	48.7	22.3	Yarnall 10725	+7	18.88	— 4	7.7
152		40	20.69	3.49	1	29	8.3	22.3	Yarnall 10724	+7	29.26	— 5	0.6
153		40	25.64	3.55	1	20	19.0	22.7	Yarnall 10778	—1	56.73	+ 0	0.6
154		40	32.05	3.55	1	22	58.9	22.7	Yarnall 10785	—2	20.31	— 1	51.1
155		40	55.83	3.55	1	22	22.6	22.7	Yarnall 10778	—1	26.54	— 2	3.0
156		45	33.03	3.48	0	44	11.6	22.5	Munich (1) 32703	+7	34.82	— 0	17.2
157		45	36.41	3.48	0	46	48.2	22.5	Munich (1) 32705	+7	32.73	+ 1	38.8
158		45	48.02	3.54	— 0	48	8.8	22.9	Yarnall 10847	—3	43.70	+ 3	24.0
159		57	50.10	0.46	+ 0	57	25.2	3.4	Yarnall 10926	—0	32.27	— 3	19.7
160		58	22.37	0.46	1	0	44.9	3.4	Yarnall 10926				
161		58	30.09	0.47	0	57	29.4	3.4	Munich (1) 33005	—0	59.85	— 0	19.4
162		58	36.54	0.47	1	1	4.8	3.4	Munich (1) 33005	—0	53.40	+ 3	16.0
163		58	49.61	0.50	0	56	47.8	3.5	Munich (1) 34	—4	43.24	+15	53.9
164		58	53.65	0.49	0	59	11.8	3.5	Munich (1) 20	—3	29.22	+12	45.2
165		59	46.60	0.47	1	9	24.1	3.5	Boss A.G. 3	—1	48.70	— 7	50 6
166		59	57.45	0.47	1	12	44.7	3.4	† Boss A.G. 3	—1	37.85	. .	. .
167	23	59	57.91	0.48	1	9	15.5	3.4	Boss A.G. 7	—2	5.59	+ 3	45.8
168	0	31	55.96	0.40	5	15	9.1	4.4	Boss A.G. 110	+3	6.16	— 8	11.4
169		31	58.43	0.41	5	10	3.2	4 4	Boss A.G. 108	+3	14.49	+ 0	8.5
170		32	2.37	0.43	5	8	58.1	4.4	Boss A.G. 132	—0	40.44	— 7	53.3
171		39	14.29	0.43	6	10	20.6	4.7	Yarnall 393	—2	49.67	— 0	23.9
172		39	17.01	0.41	6	6	36.0	4.6	Yarnall 359	+1	19.97	+ 6	13.9
173	0	39	23.62	+0.43	+ 6	9	50.2	+ 4.7	Yarnall 393	—2	40.34	— 0	54.3

Also, * Rümker 10980 +5′ 12″.3 Also, † Boss A.G. 7 +7′ 15″.0.

NOTES.

1896 *Aug.* 31st, Comet bright, with plain central condensation. *Sept.* 1st, Haze occasionally blots comet out. 4th, Hunted in vain for Spitaler's comet. Found a very faint object at 23^h 38^m —24° 35′, which I could not see on Sept. 5. 7th, Comet bright, but dimmed occasionally by haze. 11th, Comet faint; fine seeing. 15th, Comet pretty faint in bright moonlight. 16th, Moonlight too strong for comet. 24th, Comet very hard to see in bright moonlight; individual observations discrepant. 28th, Comet plain before moonrise and not difficult afterwards; seeing good. 29th, Haze dims comet, but observations good. *Oct.* 1st, Sky very clear. Comet not bright; observer's eyes in poor condition. 3d, Hunted for the star Rümker 9961 in vain. There was one of 9^M at 22^h 8^m 14^s; —18° 6′.2 (1896.0). One of 10^M followed this about 45^s at nearly the same declination. Beautiful seeing. 10th, Observations made after moon had set; companion-comets searched for, but not found. 24th, Comet quite faint, with pretty sharp nucleus; moonlight. 27th, Observations of $\Delta\alpha$ difficult; telescope unsteady. The comet had a sharp nucleus visible under strong illumination. 29th, Wires disturbed during observations. Perhaps each observation should be given half weight. Comet's nucleus bright, except when obscured by clouds. 30th, Stopped by clouds. *Nov.* 5th, Comet pretty faint, but nucleus plain. 6th, Sky very clear. 7th, Comet could not be seen when close to a 9^M star. 10th, Moon about 30° away, but comet's nucleus distinct. 23d, Comet very hard to see, because of haze and moonlight; it looked like a very faint star. 28th, Comet bright, and nucleus distinct. 30th, Wisps of haze often made comet pretty faint. *Dec.* 3d, Seeing good; when 3″ or 4″ from a star of the twelfth magnitude the comet was almost obliterated; the two looked like a double star. 5th, Seeing very steady; comet plain. 7th, Observations unsatisfactory because of haze. 22d, Observations terminated by bright moonlight. 23d, Nucleus not plain most of the time, because of haze. 24th, Comet almost stellar in appearance, but faint. 25th, Sky very clear; comet fluffy and about 30″ in diameter; it exhibited no sharp nucleus, but a strong illumination of the wires cut it down to a small bright spot. 28th, Last observation of $\Delta\delta$ very difficult on account of haze. 1897 *Jan.* 4th, The measures of $\Delta\alpha$ were made with the chronograph and sidereal clock, except that five measures of the first set were micrometric. Sky very clear, and definition fair, but the comet was generally a faint fluffy mass without visible nucleus. 5th, Beautiful definition; comet easily seen. 22d, Comet not very difficult, though the nucleus was not sharp; night clear and seeing good. 26th, Seeing bad; thermometer 10°; comet stellar, but very faint and difficult; in or near the zodiacal light, which was bright. *Feb.* 26th, Hunted in vain for the comet from 7^h 0^m to 7^h 40^m. But it was near a 9^M star in the zodical light, not far from brilliant *Venus*, and low in the west.

OBSERVATIONS OF THE PARTIAL SOLAR ECLIPSE OF 1897 JULY 29,

By E. E. BARNARD.

The partial eclipse of the sun on the morning of July 29 was observed here with the 12-inch equatorial. All the observations but the first contact were made with a polarizing eyepiece, with a magnifying power of about 200 diameters.

The conditions were very favorable, and the sky a fine rich blue. The first contact was observed by projecting the image of the sun from a temporary finder.

During the progress of the eclipse, the moon occulted a fine large sunspot. At the disappearance of this object, contact of the limb of the moon with both ends of the spot were observed, but at emergence it had partly reappeared before it was noticed, so that only the last contact of the moon with it could be observed.

As the conditions were very favorable for the purpose, a careful search was made for any evidence of the moon's being visible off the disc of the sun. At first there seemed to be such a phenomenon — the limb of the moon appeared to be projected some 2′ or 3′ from the edge of the sun. This looked so real that, without further investigation, one might have recorded the limb as being visible on the sky. A closer inspection, however, with the bright sun occulted, showed that this was an illusion of some kind due to the condition of the eye or eyepiece, for no trace of the dark limb could be seen even close up to the edge of the sun, when the disc of the sun was hidden from view. By uncovering the sun the phenomenon was very persistent. There was no doubt, however, but that it was not real. I have seen it stated that some observers have seen the moon projected on the sky during the partial phase of an eclipse. Is it possible that something of this kind has been seen? Near totality one would expect the moon to be outlined against the corona.

At present we have no instrument for the determination of accurate time. On this occasion a comparison was had with the Western Union time-signals from Washington at 11 o'clock on the 29th and 30th by means of a watch.

I wish here to express my very great obligation to Mr. W. H. Wright, who kindly made the comparisons at the railway station a mile from the observatory. His skill and care will have insured the accuracy of these comparisons. The watch was repeatedly compared with a chronometer at the observatory.

The approximate position of the Yerkes Observatory, as determined by Mr. Wright from observations with a very small universal instrument, is

Longitude west of Greenwich,	$5^h\ 54^m\ 14^s \pm$
Latitude,	$+42°\ 34'\ 15'' \pm$

Observations (90th meridian time).

	h m s	
First contact, 1897 July 28,	19 35 29.6	Fair observation
Last contact,	21 45 22.0	Good "
Duration of eclipse,	2 9 52.4	

Following are the observations of the contact of the moon's limb with the large sunspot.

At Disappearance.

	h m s
First contact,	19 53 8.7
Second contact,	19 48 46.7

There is evidently an error of five minutes in one of these observations. Should it be deemed of sufficient importance, it will be possible by reference to photographs to show which observation is in error. There was a smaller spot some distance from this one; the moon's limb passed between them, but did not occult the second one.

Last contact of the moon with the same spot, when leaving it at reappearance = $20^h\ 30^m\ 19^s.6$. In the sunspot observations the contacts refer to the edges of the umbra.

Yerkes Observatory, Williams Bay, Wis., 1897 *July* 30.

SOLAR ECLIPSE OF 1897 JULY 29,

By WM. F. RIGGE, S.J.

The solar eclipse of 1897 July 29 was observed at Creighton College Observatory with a five-inch equatorial. An enlarged image of the sun was projected upon a piece of white cardboard attached to the eye-end of the telescope. The image was slightly tremulous. The contacts were observed by me on a chronograph, and occurred $0^s.43$ and $0^s.92$ after the predicted times of the *American Ephemeris*, $7^h\ 29^m\ 3^s.00$ and $9^h\ 36^m\ 19^s.80$, a.m., Central Time (90th meridian). My brother, Joseph Rigge, S.J., noted the contacts about 1½ and 2 seconds before I did, but as he had no observing key, this interval could not be determined with accuracy. I myself am under the impression that I was about half a second late at the first contact, because I did not press the button until I saw the sun perceptibly indented. The last contact seemed to me to be well observed, although I may possibly have been late there also. Time-observations were secured with a three-inch transit the night before and after, and also during the eclipse. The Greenwich longitude of our observatory is $+6^h\ 23^m\ 46^s.96$, the latitude $+41°\ 16'\ 5''.6$, and the height of center of equatorial telescope above sea level is 1154 feet.

Creighton College Observatory, Omaha, Neb.

ON THE FORMATION OF A NEW DIVISION IN THE *B*-RING OF *SATURN*,

BY J. M. SCHAEBERLE.

During the present opposition of *Saturn* a partial division in the *B*-ring exists, which has not been visible to me in the previous oppositions of the past eight years.

The results of a few measures make the distance of the center of this division 0″.7 from the inner edge of ring *B*. The width of the division is about the same as that of the Cassini-division; but while the latter is always a conspicuous feature of the ring-system, the new division is evidently not complete, for it contains matter which reflects light to such an extent that when the conditions of seeing are not fair this new division would be overlooked. With the exception of about 30° each side of inferior and superior conjunction, the division can be traced throughout the whole remaining part of the ring, when the seeing is best.

I have not been able to see a division between the rings *B* and *C* as announced by Mr. BRENNER.

Lick Observatory, University of California, 1897 *July* 26.

MEASURES OF 70 *OPHIUCHI* (Σ2272),

BY H. S. PRITCHETT.

The following observations of position-angle and distance of 70 *Ophiuchi* were made with the 12½-inch equatorial of the Morrison Observatory. A power of 600 was used.

Epoch	Sid. Time h	Pos. Angle °	Dist. ″
1897.58	17.5	277.98	1.95
.58	16.5	276.63	1.97
.59	16.5	276.20	2.13
1897.59	16.9	275.50	2.05
1897.585		276.58	2.03

Glasgow, Mo., 1897 *Aug.* 7.

EPHEMERIS OF COMET *a* 1897 (D'ARREST'S),

BY G. LEVEAU, (*Comptes Rendus*, July 19).

Paris Mean Midnight.

1897	α h m s	Daily Motion m s	δ ° ′	Daily Motion ′	Br.
Aug. 21.5	4 3 21	+1 29	+4 9.6	−7.3	0.20
23.5	6 17	1 25	3 54.9	7.5	
25.5	9 4	1 21	3 39.7	7.8	
27.5	11 43	1 17	3 23.9	8.1	
29.5	4 14 14	+1 12	+3 7.6	−8.4	0.20
Aug. 31.5	4 16 36	+1 8	+2 50.7	−8.6	0.19
Sept. 2.5	18 49	1 3	2 33.4	8.8	
4.5	20 53	+0 59	2 15.6	−9.1	0.19
6.5	4 22 48		+1 57.3		

OBSERVATIONS OF D'ARREST'S COMET (= *a* 1897),

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY,

BY R. G. AITKEN.

1897 Mt. Hamilton M.T.	*	No. Comp.	☄—* Δα	☄—* Δδ	☄'s apparent α	☄'s apparent δ	log *p*Δ for α	log *p*Δ for δ
			s	′ ″	h m s	° ′ ″		
July 7 14 35 46	1	12, 12	−13.48	−1 18.2	2 26 48.93	+6 32 0.2	*n*9.650	0.702
8 14 26 29	3	12, 12	+22.45	−0 44.4	2 29 30.77	+6 33 5.0	*n*9.654	0.705

Mean Places for 1897.0 of Comparison-Stars.

*	α h m s	Red. to app. place s	δ ° ′ ″	Red. to app. place ″	Authority
1	2 27 1.42	+1.99	+6 33 2.0	+16.1	Comparison with (2)
2	2 27 33.16	. .	+6 30 4.0	. .	Grant 571
3	2 29 6.30	+2.02	+6 33 33.2	+16.2	Comparison with (2)

Δα was measured directly with the micrometer on both nights.

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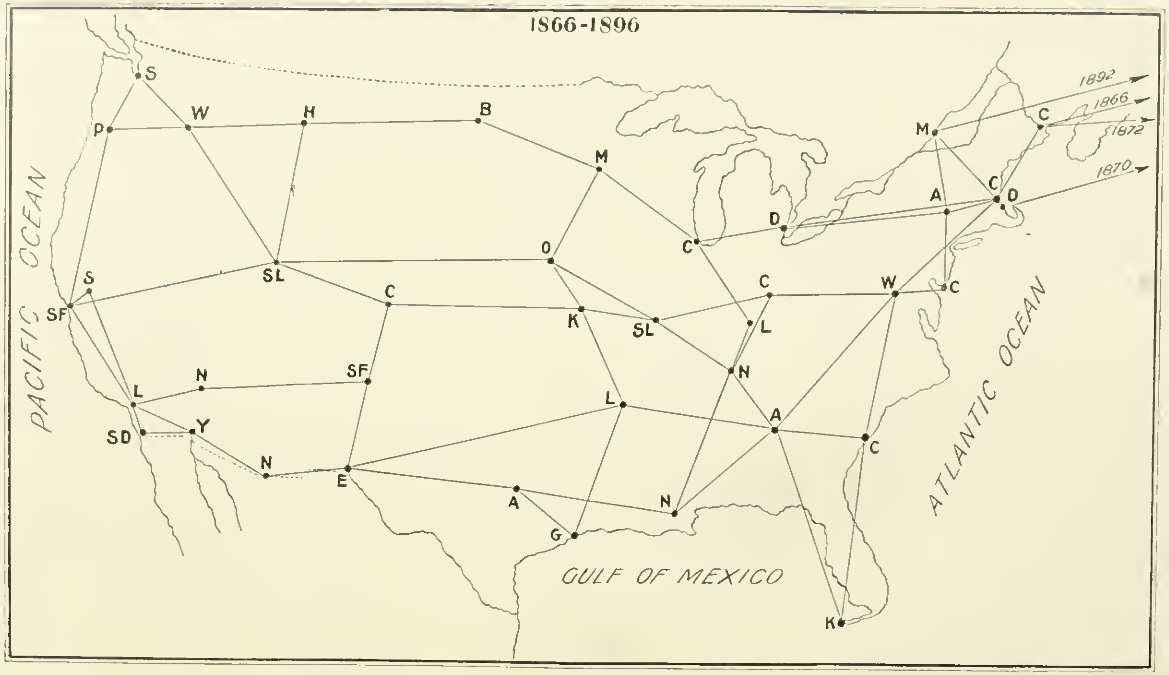
TELEGRAPHIC LONGITUDE NET OF THE UNITED STATES.



1866-1896

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THE TELEGRAPHIC LONGITUDE NET OF THE UNITED STATES AND ITS CONNECTION WITH THAT OF EUROPE, AS DEVELOPED BY THE COAST AND GEODETIC SURVEY BETWEEN 1866 AND 1896,*

BY CHARLES A. SCHOTT, ASSISTANT.

The early determination by astronomical methods of a standard longitude, for the use of the surveys and charts of the United States, was a matter of prime importance to the operations of the U.S. Coast Survey, and it spared no labor to obtain the most reliable value by the means then available. As the result of his computations and discussions, S. C. WALKER, Assistant, reported under date of September, 1851, the following values for the longitude of the Cambridge Observatory:

		West of Gr. h m s
(*A*).	From moon culminations,	4 44 28.42
(*B*).	From eclipses, transits and occultations,	4 44 29.64
(*C*).	By chronometric expeditions,	4 44 30.10

When in May, 1844, MORSE flashed the first telegraphic messages over the wires between Washington and Baltimore, with a time of transmission apparently too short for measure, the idea of utilizing the new method for the determination of the difference of longitude must have readily suggested itself to the mind of astronomers. In the autumn of 1845 Superintendent BACHE instructed Assistant WALKER to devise practical means for the employment of the electric telegraph for longitude work. With the cooperation of the U.S. Naval Observatory, the cities of Washington and Philadelphia were connected on October 10, 1846, and their difference of longitude was found to be $7^{m}\,34^{s}.3$. After the retirement of Professor WALKER in 1852, Dr. B. A. GOULD took charge of the longitude work of the survey up to 1867; the Coast Survey Report for that year contains his report "On the longitude between America and Europe from signals through the Atlantic cable." The resulting longitude of the Cambridge Observatory from the measures over the land lines and cable of 1866 was

$$4^{h}\ 44^{m}\ 30^{s}.85.$$

Other cable determinations were secured by the Coast Survey in 1870 and 1872, but the latest determination in 1892 is due to the cooperation of the McGill College Observatory at Montreal, Canada, with the Greenwich Observatory. The Survey is indebted to Prof. C. H. McLEOD, in charge of the McGill Observatory, for the courtesy of communicating the resulting difference of longitude, Montreal and Greenwich, in advance of its publication. The final value for the longitude of the Harvard Observatory at Cambridge, as adjusted in June, 1897, is

$$4^{h}\ 44^{m}\ 31^{s}.046 \pm 0^{s}.048.$$

The standard longitude for the geodetic work of the Survey will, of course, depend upon the connection of a number of telegraphic longitude and triangulation stations in order to eliminate, as far as may be, local deflections.

The longitude net, as developed during 30 years, is shown on the accompanying chart; inclusive of some European stations it is composed of 45 stations connected by 72 links. It will be seen that practically three lines cross the continent, one near our northern boundary, one near the southern, and an intermediate one, and the three are connected by cross lines. Only those determinations were admitted into the scheme for which the personal equations were eliminated by interchange of places of the observers; in a very few exceptions the personal equations were otherwise ascertained, and there are a few links included which are due to other observers than those of the Coast and Geodetic Survey.

The original paper, which will form Appendix No. 2 of the Annual Report for the year 1897, will contain, besides the introduction and historical sketch of the telegraphic method, information respecting location, observers, instruments, method of observing and computing, as well as complete abstracts of the individual or nightly results for every determination. The treatment for adjustment of the differences of longitudes entering into the net, is the same as that followed by me in the preliminary adjustment of longitudes given in Appendix No. 11, Coast Survey Report for 1884. Weights are introduced depending upon the probable errors assigned to the results, but the maximum weight admitted is that corresponding to a probable error of $\pm 0^{s}.008$, values smaller than this received the same weight. There were 28 observation equations, and the corrections resulting from the solution of the normal equations are given below, together with the 72 observed and corrected differences of longitude.

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* Abstract of paper published with the approval of W. W. DUFFIELD, Superintendent of the U.S. Coast and Geodetic Survey. The paper will appear in full as Appendix No. 2 in the Annual Report of the Superintendent for the fiscal year 1897.

Table of Observed Differences of Longitude with Probable Error, and of Corrections Due to Adjustment of the Net, together with Resulting Differences of Longitude.

Date of Observation		Western Station	Point of Refer.	Eastern Station	Point of Refer.	Observed Difference of Longitude with Probable Error	Cor-rection	Adjusted Difference of Longitude
Year	Month							
						h m s s	s	h m s
1866	Oct. and Nov.	Heart's Content, N.F.,	Tr.	Foilhommerum, Ire.	Tr.	2 51 56.364 ± 0.029	+0.015	2 51 56.379
1866	Nov.	Foilhommerum, Ireland	Tr.	Greenwich, Eng.	Transit Circle	41 33.34 ± 0.06	+ .069	41 33.409
1866	Dec.	Calais, Me.	Tr.	Heart's Content, NF	Tr.	55 38.00 ± 0.06	+ .069	55 38.069
1869	Feb.	Salt Lake City, Utah	Tr.	Omaha, Neb.	Tr.	1 3 49.113 ± 0.016	− .027	1 3 49.086
1869–70	Dec. Jan. Feb.	Cambridge, Mass.	Dome	Duxbury, Mass.	Tr.	1 50.191 ± 0.022	− .003	1 50.188
1870	Jan. and Feb.	Duxbury, Mass.	Tr.	Brest, France	Tower of St. Louis	4 24 43.276 ± 0.047	− .015	4 24 43.261
1872	July	Brest, France	Tower of St. Louis	Greenwich, Eng.	Transit Circle	17 57.598 ± 0.022	− .001	17 57.597
1872	July	Brest, France	Tower of St. Louis	Paris, France	M of F	27 18.533 ± 0.038	+ .032	27 18.565
1872	July	St. Pierre Isl., Miquelon	Tr.	Brest, France	Tower of St. Louis	3 26 44.810 ± 0.027	+ .020	3 26 44.830
1872	July and Aug.	Cambridge, Mass.	Dome	St. Pierre Isl., Mique.	Tr.	59 48.608 ± 0.021	+ .011	59 48.619
1872	Aug. and Sept.	Greenwich, England	Transit Circle	Paris, France	M of F	9 21.000 ± 0.038	− .032	9 20.968
1879	Jan. Feb. Mar.	Atlanta, Ga.	Tr.	Washington, D.C.	Dome old site	29 21.192 ± 0.016	− .007	29 21.185
1879	Nov. and Dec.	Nashville, Tenn.	Tr.	Louisville, Ky.	Tr.	4 4.451 ± 0.013	− .004	4 4.447
1879–80	Dec. and Jan.	Nashville, Tenn.	Tr.	Atlanta, Ga.	Tr.	9 34.760 ± 0.012	− .015	9 34.745
1880	Feb. and Mar.	New Orleans, La.	Transit of 1895	Nashville, Tenn.	Tr.	13 8.677 ± 0.009	+ .003	13 8.680
1880	Mar. and Apr.	New Orleans, La.	Transit of 1895	Atlanta, Ga.	Tr.	22 43.371 ± 0.013	+ .054	22 43.425
1880	May	Atlanta, Ga.	Tr.	Charleston, S.C.	Tr.	17 49.222 ± 0.010	+ .040	17 49.262
1881	May	Washington, D.C.	Dome old site	Cape May, N.J.	Tr.	8 29.074 ± 0.009	+ .034	8 29.108
*1881	May and June	Detroit, Mich.	Transit of 1891	Cambridge, Mass.	Dome	47 40.806 ± 0.013	− .022	47 40.784
1881	July and Aug.	Cincinnati, Ohio	Dome	Washington. D.C.	Dome old site	29 29.259 ± 0.011	− .014	29 29.245
1881	Aug. and Sept.	Nashville, Tenn.	Tr.	Cincinnati, Ohio	Dome	9 26.682 ± 0.006	+ .003	9 26.685
1881	Sept. and Oct.	Saint Louis, Mo.	Transit of 1882	Cincinnati, Ohio	Dome	23 7.894 ± 0.015	− .036	23 7.858
1881	Oct. and Nov.	Saint Louis, Mo.	Transit of 1882	Nashville, Tenn.	Tr.	13 41.207 ± 0.013	− .034	13 41.173
1882	Sept. and Oct.	Kansas City, Mo.	Tr.	Saint Louis, Mo.	Transit of 1882	17 32.183 ± 0.011	− .035	17 32.148
1882	Oct. and Nov.	Omaha, Neb.	Tr.	Saint Louis, Mo.	Transit of 1882	22 56.831 ± 0.010	.000	22 56.831
1882–83	Nov. Dec. Jan.	Omaha, Neb.	Tr.	Kansas City, Mo.	Tr.	5 24.626 ± 0.016	+ .057	5 24.683
*1883	June	Montreal, Canada	Tr. of McG. Ob.	Cambridge, Mass.	Dome	9 47.549 ± 0.019	+ .039	9 47.588
1883	Sept. Oct. Nov.	Chicago, Ill.	Transit of 1891	Louisville, Ky.	Tr.	7 25.808 ± 0.010	+ .002	7 25.810
1885	Apr. and May	Galveston, Texas	Transit of 1895	Little Rock, Ark.	Tr.	10 4.192 ± 0.011	+ .009	10 4.201
1885	May and June	Kansas City, Mo.	Tr.	Little Rock, Ark.	Tr.	9 15.644 ± 0.003	+ .033	9 15.677
1885	July and Aug.	Colorado Springs, Colo.	Tr.	Kansas City, Mo.	Tr.	40 55.327 ± 0.011	− .021	40 55.306
1886	May and June	Santa Fé, N.M.	Tr.	Colorado Spgs., Col.	Tr.	4 30.107 ± 0.012	− .012	4 30.095
1886	Aug. and Sept.	Salt Lake City, Utah	Tr.	Colorado Spgs., Col.	Tr.	28 18.471 ± 0.008	− .008	28 18.463
1887	May and June	San Francisco, Cal.	Transit Laf. Park	Salt Lake City, Utah	Tr.	42 7.696 ± 0.011	− .008	42 7.688
1887	June July Aug.	Portland, Oregon	Tr.	San Francisco, Cal.	Transit Laf. Park	59.983 ± 0.015	− .006	59.977
1887	Sept.	Portland, Oregon	Tr.	Walla Walla, Wash.	Tr.	17 19.503 ± 0.011	+ .004	17 19.507
1887	Sept. and Oct.	Walla Walla, Wash.	Tr.	Salt Lake City, Utah	Tr.	25 48.186 ± 0.009	− .028	25 48.158
1888	June and July	Portland, Oregon	Tr.	Seattle, Wash.	Tr.	1 22.486 ± 0.026	− .006	1 22.480
1888	Aug.	Seattle, Wash.	Tr.	Walla Walla, Wash.	Tr.	15 57.028 ± 0.009	− .001	15 57.027
1888	Aug. and Sept.	Walla Walla, Wash.	Tr.	Helena, Montana	Tr.	25 14.510 ± 0.006	+ .032	25 14.542
1888–89	Dec. and Jan.	San Francisco, Cal.	Transit Laf. Park	Sacramento, Cal.	Tr.	3 44.487 ± 0.008	− .013	3 44.474
1889	Mar. and Apr.	Sacramento, Cal.	Tr.	Los Angeles, Cal.	Tr.	12 56.840 ± 0.010	− .014	12 56.826
1889	Apr. and May	San Francisco, Cal.	Transit Laf. Park	Los Angeles, Cal.	Tr.	16 41.282 ± 0.009	+ .018	16 41.300
1889	May and June	Los Angeles, Cal.	Tr.	Needles, Cal.	Tr.	14 36.728 ± 0.016	− .003	14 36.725
1890	July	Helena, Montana	Tr.	Salt Lake City, Utah	Tr.	33.577 ± 0.013	+ .039	33.616
1890	July and Aug.	Helena, Montana	Tr.	Bismarck, N.D.	Tr.	45 0.839 ± 0.012	+ .012	45 0.851
1890	Aug.	Bismarck, N.D.	Tr.	Minneapolis, Minn.	Tr.	3 30 11.080 ± 0.006	+0.013	3 30 11.093

* This determination depends upon other than Coast and Geodetic Survey authority.

Date of Observation		Western Station	Point of Refer.	Eastern Station	Point of Refer.	Observed Difference of Longitude with Probable Error	Correction	Adjusted Difference of Latitude
Year	Month					h m s s	s	h m s
1891	May and June	Cape May N.J.	Tr.	Albany, N.Y.	Dome old site	3 4 43.020 ± 0.010	+ 0.033	3 4 43.053
1891	June and July	Detroit, Mich.	Transit of 1891	Albany, N.Y.	Dome old site	37 11.845 ± 0.005	− .007	37 11.838
1891	July	Chicago, Ill.	Transit of 1891	Detroit, Mich.	Transit of 1891	18 17.634 ± 0.006	− .018	18 17.616
1891	Aug.	Minneapolis, Minn.	Tr.	Chicago, Ill.	Transit of 1891	22 27.414 ± 0.010	− .015	22 27.399
1891	Aug. and Sept.	Omaha, Neb.	Tr.	Minneapolis, Minn.	Tr.	10 49.269 ± 0.010	− .027	10 49.242
1892	Feb. and Mar.	Los Angeles, Cal.	Tr.	San Diego, Cal.	Tr.	4 22.786 ± 0.010	+ .027	4 22.813
1892	March	San Diego, Cal.	Tr.	Yuma, Arizona	Tr.	10 9.114 ± 0.005	+ .026	10 9.140
1892	Mar. and Apr.	Los Angeles, Cal.	Tr.	Yuma, Arizona	Tr.	14 31.974 ± 0.006	− .021	14 31.953
1892	April	Yuma, Arizona	Tr.	Nogales, Arizona	Tr.	14 43.690 ± 0.007	+ .006	14 43.696
1892	Apr. and May	Nogales, Arizona	Tr.	El Paso, Texas	Tr.	17 48.520 ± 0.009	+ .006	17 48.526
*1892	?	Montreal, Canada	Tr. of McG. Ob.	Greenwich, Eng.	Transit Circle	4 54 18.67 ± ?	− .036	4 54 18.634
1893	Feb. and Mar.	El Paso, Texas	Tr.	Little Rock, Ark.	Tr.	56 51.681 ± 0.009	− .022	56 51.659
1895	Feb. and Mar.	Needles, Cal.	Tr.	Santa Fé, N.M.	Tr.	34 38.032 ± 0.013	− .001	34 38.031
1895	March	El Paso, Texas	Tr.	Santa Fé, N.M.	Tr.	2 10.593 ± 0.009	− .012	2 10.581
1895	April	El Paso, Texas	Tr.	Austin, Texas	Tr.	35 0.322 ± 0.004	+ .040	35 0.362
1895	May and June	Austin, Texas	Tr.	Galveston, Texas	Transit of 1895	11 47.087 ± 0.004	+ .009	11 47.096
1895	June and July	Austin, Texas	Tr.	New Orleans, La.	Transit of 1895	30 40.230 ± 0.010	+ .031	30 40.261
1895	Aug. and Sept.	Cambridge, Mass.	Dome	Calais, Me.	Tr.	15 23.187 ± 0.007	+ .002	15 23.189
1896	Feb. and Mar.	Key West, Fla.	Tr.	Charleston, S.C.	Tr.	7 29.509 ± 0.003	− .006	7 29.503
1896	March	Atlanta, Ga.	Tr.	Key West, Fla.	Tr.	10 19.765 ± 0.067	− .006	10 19.759
1896	April	Little Rock, Ark.	Tr.	Atlanta, Ga.	Tr.	31 32.369 ± 0.005	+ .020	31 32.389
1896	Apr. and May	Charleston, S.C.	Tr.	Washington, D.C.	Dome old site	11 31.888 ± 0.005	+ .035	11 31.923
1896	May and June	Washington, D.C.	Dome old site	Cambridge, Mass.	Dome	23 41.138 ± 0.014	− .031	23 41.107
1896	Aug. and Sept.	Albany, N.Y.	Dome old site	Cambridge, Mass.	Dome	10 28.926 ± 0.008	+ .020	10 28.946
1896	Sept. and Oct.	Albany, N.Y.	Dome old site	Montreal, Canada	Transit McG. Ob.	41.352 ± 0.007	+0.006	41.358

* This determination depends upon other than Coast and Geodetic Survey authority.

The satisfactory character of the observations may be judged of by the smallness of the probable errors of measure, as well as by the small corrections needed to satisfy the conditions. The average value of the former, without regard to sign, is 0s.020, and the probable error of a single resulting difference of longitude, as adjusted, is ± 0s.024. A direct computation for the probable error of the resulting longitude of Washington, old Naval Observatory, gave the value ± 0s.049, and a similar computation for San Francisco, Lafayette Park Observatory, gave ± 0s.055. In the present adjustment the largest correction is less than 0s.07, and this falls upon the old (1866) lines from Foilhommerum to Greenwich, and from Calais to Heart's Content, determinations which are somewhat out of date as regards accuracy. We have here retained the value of $\Delta\lambda$ Greenwich and Paris as found by the American party in cooperation with the respective observatories, since no agreement has been reached as to its true value; our determination, however, is near the mean value of the numerous direct and indirect measures in the European net.

Putting our results together, we have the following table of resulting longitudes, west of Greenwich:

	h	m	s
Greenwich, England. Transit circle,	0	0	0.000
Paris, France. Meridian of France,	0	9	20.968 E.
Brest, France. Tower of Saint Louis,	0	17	57.597
Foilhommerum, Ireland. Transit,	0	41	33.409
Heart's Content, Newfoundland. Transit,	3	33	29.788
Saint Pierre Isl., Miquelon Group. Transit,	3	44	42.427
Calais, Me. Transit,	4	29	7.857
Duxbury, Mass. Transit,	4	42	40.858
Cambridge, Mass. Dome Harv. Coll. Obs'y,	4	44	31.046
Montreal, Can. Transit McGill Coll. Obs'y,	4	54	18.634
Albany, N.Y. Dome Dudley Obs'y, old site,	4	54	59.992
Cape May, N.J. Transit,	4	59	43.045
Washington, D.C. Dome U.S.N. Obs'y, old site,	5	8	12.153
Charleston, S.C. Transit,	5	19	44.076
Key West, Fla. Transit,	5	27	13.579
Detroit, Mich. Transit of 1891,	5	32	11.830
Atlanta, Ga. Transit of 1896,	5	37	33.338
Cincinnati, Ohio. Dome Mt. Lookout Obs'y,	5	37	41.398
Louisville, Ky. Transit,	5	43	3.636
Nashville, Tenn. Transit,	5	47	8.083
Chicago, Ill. Transit of 1891,	5	50	29.446
New Orleans, La. Transit of 1895,	6	0	16.763
St. Louis, Mo. Transit 1882 of Wash. Univ.,	6	0	49.256
Little Rock, Ark. Transit,	6	9	5.727
Minneapolis, Minn. Transit,	6	12	56.845
Kansas City, Mo. Transit,	6	18	21.404
Galveston, Tex. Transit of 1895,	6	19	9.928
Omaha, Neb. Transit,	6	23	46.087
Austin, Tex. Transit,	6	30	57.024

	h m s
Bismarck, N.D. Transit,	6 43 7.938
Colorado Springs, Colo. Transit of 1886,	6 59 16.710
Santa Fé, N.M. Transit,	7 3 46.805
El Paso, Tex. Transit,	7 5 57.386
Nogales, Ariz. Transit,	7 23 45.912
Salt Lake City, Utah. Transit,	7 27 35.173
Helena, Mont. Transit,	7 28 8.789
Needles, Cal. Transit,	7 38 24.836
Yuma, Ariz. Transit,	7 38 29.608
San Diego, Cal. Transit of 1892,	7 48 38.748
Los Angeles, Cal. Transit of 1892,	7 53 1.561
Walla Walla, Wash. Transit,	7 53 23.331
Sacramento, Cal. Transit,	8 5 58.387
Seattle, Wash. Transit,	8 9 20.358
San Francisco, Cal. Transit Lafayette Park,	8 9 42.861
Portland, Oregon. Transit,	8 10 42.838

In conclusion, the paper contains the longitudes of a few prominent observatories directly connected with the Coast and Geodetic Survey system; they are as follows:

(1). The U.S. Naval Observatory, new site on Georgetown Heights (since 1893).

* U.S. Naval Observatory, *new* site and *old* site, observed in 1893, $\Delta\lambda = 3^{s}.670 \pm 0^{s}.012$.

U.S. Naval Observatory, *old* site, and U.S. Coast and Geodetic Survey Office, observed in 1896, $\Delta\lambda = 10^{s}.462 \pm 0^{s}.008$.

U.S. Naval Observatory, *new* site, and U.S. Coast and Geodetic Survey, Office station, observed in 1897, $\Delta\lambda = 14^{s}.065 \pm 0^{s}.006$. The closing error of the triangle is $0^{s}.067 \pm 0^{s}.016$. The adjusted values of $\Delta\lambda$ are $3^{s}.631$, $10^{s}.444$ and $14^{s}.075$, and the resulting longitudes become

U.S. Naval Observatory, *new* site, meridian of clock room, $5^{h}\ 8^{m}\ 15^{s}.784 \pm 0^{s}.050$.

U.S. Coast and Geodetic Survey, Office station, $5^{h}\ 8^{m}\ 1^{s}.709$.

(2). The longitude of the Lick Observatory on Mount Hamilton, Cal., depends upon the observed difference $\Delta\lambda$ (October and November, 1888), between it and the Lafayette Park transit at San Francisco; we have $\Delta\lambda = 3^{m}\ 7^{s}.966 \pm 0^{s}.013$, hence longitude of Lick Observatory meridian of transit house, $8^{h}\ 6^{m}\ 34^{s}.895 \pm 0^{s}.057$.

(3). The difference of longitude (observed in 1886) between the Ogden Observatory established by the U.S. Engineers in 1873 and Salt Lake transit, was $24^{s}.533 \pm 0^{s}.011$, hence the longitude of the Engineer's Observatory (east transit in west room), $7^{h}\ 27^{m}\ 59^{s}.706 \pm 0^{s}.055$.

(4). The astronomic observatory at Detroit, established by the U.S. Lake Survey, was found to be $0^{s}.366$ west of the C. and G. station of 1891 at Detroit, hence longitude of the U.S. Lake Survey Observatory, $5^{h}\ 32^{m}\ 12^{s}.196 \pm 0^{s}.050$.

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* This determination rests upon observations by the Observatory staff.

PHOTOGRAPH OF AN AUGUST METEOR.

By E. E. BARNARD.

The full moon interfered greatly this year with the visibility of the August meteors.

Taking into account the effect of moonlight, there did not seem to be more than the average number, if as many as usual.

Photographic plates were exposed on the mornings of August 10th, 11th and 12th, after moonset, in hopes of securing meteor trails. Two cameras were used; a $1\frac{1}{2}$-inch lantern lens of 6.4-inch focus, and a $3\frac{4}{10}$-inch Clark portrait lens of 19.4-inch focus.

Only one meteor was secured — a very fine one. This object left its trail on both plates. The full length of its path, about 8°, is recorded. The approximate positions of the ends of the trail, taken from Proctor's smaller star atlas, are

$$\left.\begin{array}{llll} \text{Beginning,} & \alpha = 2^{h}\ 59^{m}, & \delta = & +23^{\circ}.7 \\ \text{Ending,} & 2\ \ 59\ , & & +32.0 \end{array}\right\} 1880$$

the direction being due south.

The exposure given these plates was

1897 August $10^{d}\ 15^{h}\ 19^{m}$ to $15^{h}\ 49^{m}$.

The actual meteor was not seen, so that the exact time of its flight is unknown.

This must have been a very bright meteor, as the trail, which is perfectly straight, is strong and clear. Near the southern end of its path it evidently exploded, as there is a great enlargement of the trail at that point. The path continues beyond this somewhat, but fainter, and there is a second minor explosion about 1° from the first.

I hope to be able to secure valuable results in photographing the meteors in November coming.

In my note (*A.J.* 389, p. 40) on the November meteors of last year, it is left a little uncertain as to the exact date of the observation, though it would be inferred from the date of the note the observations were made on the night of November 13th — the morning of the 14th.

Yerkes Observatory, Williams Bay, Wis., 1897 *Aug.* 13.

OBSERVATIONS OF D'ARREST'S PERIODIC COMET = *a* 1897,

MADE AT THE LICK OBSERVATORY OF THE UNIVERSITY OF CALIFORNIA,

By C. D. PERRINE.

1897 Mt. Hamilton M.T.	*	No. Comp.	☄ − * $\Delta\alpha$	☄ − * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
h m s			m s	′ ″	h m s	° ′ ″		
July 1 14 58 32	1	*d*10 , 9	+0 37.13	+ 2 33.6	2 10 3.09	+6 21 22.5	*n*9.638	0.700
2 14 49 42	3	*d*10 , 8	−0 0.71	+ 9 49.1	2 12 52.48	+6 23 47.6	*n*9.644	0.701
9 15 16 33	4	10 , 6	+1 50.07	+ 9 59.4	2 32 15.54	+6 33 29.5	*n*9.613	0.690
10 14 59 39	5	12 , 6	+1 41.49	+ 4 1.1	2 34 56.20	+6 34 43.7	*n*9.629	0.695
15 15 11 6	6	*d*10 , 6	+0 14.26	+ 2 49.4	2 48 1.31	+6 34 49.0	*n*9.612	0.690
16 15 1 16	8	*d*10 , 8	+0 5.15	+ 1 11.4	2 50 32.71	+6 34 12.5	*n*8.622	0.692
25 15 18 9	10	10 , 8	+0 32.49	− 5 49.8	3 12 14.79	+6 19 46.2	*n*9.582	0.686
26 14 37 52	11	*d*10 , 8	+0 19.71	+ 0 20.0	3 14 28.54	+6 17 13.5	*n*9.627	0.695
27 15 10 14	13	*d*10 , 8	−0 16.85	+ 0 26.4	. . . .	. . . .	. .	. .
28 15 30 5	15	*d*10 , 8	−0 12.96	− 4 27.9	. . . .	. . . .	. .	. .
30 14 49 44	16	10 , 9	−0 46.58	− 3 15.2	. . . .	. . . .	. .	. .
31 15 11 8	17	10 , 8	−2 32.00	+ 0 42.3	3 25 31.27	+6 1 23.8	*n*9.579	0.688
Aug. 1 15 11 6	18	12 , 8	−0 25.60	− 3 4.8	3 27 37.70	+5 57 36.8	*n*9.575	0.687
2 14 30 36	19	*d*10 , 8	+0 15.83	−10 55.6	3 29 39.16	+5 53 45.4	*n*9.622	0.695
2 15 12 51	20	12 , 8	−1 5.24	+ 0 11.9	3 29 42.32	+5 53 48.1	*n*9.571	0.688
3 14 59 10	21	10 , 8	+0 56.34	− 3 55.9	3 31 43.92	+5 49 40.5	*n*9.592	0.696
6 15 36 45	22	10 , 6	−2 27.45	− 7 54.7	3 37 47.08	+5 36 2.5	*n*9.501	0.683

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	2 9 24.05	+1.91	+6 18 33.5	+15.4	Micrometer-comparison with *2
2	2 9 7.23	+1.91	+6 10 11.8	+15.4	Paris 2781
3	2 12 51.27	+1.92	+6 13 42.9	+15.6	Weisse's Bessel 149
4	2 30 23.43	+2.04	+6 23 13.8	+16.3	Paris 3205
5	2 33 12.65	+2.06	+6 30 26.2	+16.4	Weisse's Bessel 520
6	2 47 44.88	+2.17	+6 31 42.6	+17.0	Micrometer-comparison with *7
7	2 50 1.04	+2.16	+6 32 49.7	+17.0	½ (Paris 3576 + W.B. 830)
8	2 50 25.37	+2.19	+6 32 55.5	+17.2	Micrometer-comparison with *9
9	2 50 1.04	+2.19	+6 32 49.7	+17.2	½ (Paris 3576 + W.B. 830)
10	3 11 39.96	+2.34	+6 25 18.2	+17.8	⅓ (2 Paris 3923 + W.B. 154)
11	3 14 6.47	+2.36	+6 16 35.6	+17.9	Micrometer-comparison with *12
12	3 11 39.96	+2.38	+6 25 18.2	+18.0	⅓ (2 Paris 3923 + W.B. 154)
13	3 17 . .	. .	+6 14 . .	. .	Micrometer-comparison with *14, see note *a*
14	3 21 . .	. .	+6 18 . .	. .	DM. +6°530 $(8^{M}.8)$
15	3 19 . .	. .	+6 16 . .	. .	Micrometer-comparison with *14, note *b*
16	3 24 . .	. .	+6 7 . .	. .	DM. +5°499 $(8^{M}.7)$
17	3 28 0.83	+2.44	+6 0 23.2	+18.3	Weisse's Bessel 462
18	3 28 0.83	+2.47	+6 0 23.2	+18.4	Weisse's Bessel 462
19	3 29 20.84	+2.49	+6 4 22.6	+18.4	Paris 4229
20	3 30 45.08	+2.48	+5 53 17.8	+18.4	B.B. VI +5°516
21	3 30 45.08	+2.50	+5 53 17.8	+18.6	B.B. VI +5°516
22	3 40 11.98	+2.55	+5 43 38.6	+18.6	½ (Grant "879 +" Pulkowa 544)

a. The measured differences between the apparent places of *s 13 and 14 are, $\Delta\alpha\ -4^{m}\ 13^{s}.03$, $\Delta\delta\ -4'\ 21''.5$.

b. The differences between the apparent places of *s 15 and 14 were found to be $\Delta\alpha\ -2^{m}\ 2^{s}.05$, $\Delta\delta\ -2'\ 27''.7$.

d. Indicates that $\Delta\alpha$ was measured directly with the micrometer.

The observations of July 15, 16, 25, 27, 28 and Aug. 1 were made with the 36-inch equatorial, the others with the 12-inch equatorial.

In the early part of July the comet as seen with the 36-inch telescope and a power of 270, was about 2′ in diameter with a bright central condensation of 20″ to 30″ diameter. At times a nucleus was to be seen, some 3″ or 4″ in diameter, but not stellar and not much brighter than the surrounding condensation. This nucleus was not exactly central but was a little south, preceding the center.

For about two weeks after rediscovery the comet seemed to retain its brightness or even to increase somewhat, but recently the decline has been noticeable although slow.

Mt. Hamilton, 1897 *August* 14.

MAXIMA AND MINIMA OF LONG-PERIOD VARIABLES,

By J. A. Parkhurst.

267. *V Andromedae.*

This star was invisible (limit 12^{M}) 1897 May 24. It was found $9^{M}.8$, July 21, and rose to a maximum, $9^{M}.0$, July 26, then fell to $10^{M}.0$ at the last comparison, Aug. 27. I have 8 observations.

659. *X Cassiopeae.*

My continuous watch on this star yields a minimum, $12^{M}.0$, 1897 March 3. The interval between my two observed maxima is 364 days, and between my two minima, 374 days. The minima have followed the maxima by 136 and 146 days.

678. *U Persei.*

My watch on this star was interrupted from 1897 Feb. 2 to May 3. It was then $12^{M}.0$, and rose to $10^{M}.0$ by the last of June. Comparison with the mean curve indicates a minimum about May 1 with an uncertainty of perhaps 10 days.

4315. *R Comae.*

After the maximum of August, 1896, I have 3 observations on the descending branch of the curve: Nov. 12, $11^{M}.1$; Dec. 2, $11^{M}.9$; 1897 Jan. 7, $12^{M}.8$. After the minimum it was first seen July 2, at $11^{M}.8$. It rose rapidly, reaching $8^{M}.8$ Aug. 1, and $8^{M}.5$ Aug. 6. During the rest of August its light seemed quite constant, the estimates being about equally divided between $8^{M}.5$ and $8^{M}.6$, the last estimate, Aug. 29, being $8^{M}.5$. A slight maximum at $8^{M}.5$ is uncertainly indicated for Aug. 9, but the bright moon makes this somewhat doubtful. I have 5 observations in July and 9 in August.

5601. *S Ursae minoris.*

I have 27 observations of this star between the minimum of 1896 June 27 and 1897 July 8. It rose slowly from $11^{M}.4$ to a maximum, $7^{M}.2$, 1896 Dec. 14, then fell, still more slowly, to a minimum, $11^{M}.8$, 1897 May 28. The interval between my two observed maxima is 322 days, between the two minima, 335 days. The minima have followed the maxima by 155 and 168 days.

6549. *W Lyrae.*

When first seen this season, 1897 May 15, this star was $9^{M}.1$. It fell rapidly to a well defined minimum, $12^{M}.5$, July 19, then rose at about the same rate to $10^{M}.0$, Aug. 30. The curve resembles closely that of 1896 October to December, reported in *A.J.*, no. 397, the mean interval between corresponding points on the two curves being 206 days. This period does not seem to be contradicted either by the Durchmusterung or the Lund observations mentioned in *Astronomische Nachrichten*, No. 3329.

7085. *RT Cygni.*

A minimum, $12^{M}.2$, 1897 May 9, is indicated by 10 observations between May 3 and July 5. The rise after minimum was rapid and uniform, reaching $8^{M}.9$ at the last observation.

7792. *SS Cygni.*

This season's observations of this remarkable star began May 28, at which time, and also May 30, I found it at normal light, $11^{M}.2$. Clouds prevented further observation till June 7, when I found it $8^{M}.6$. June 11 it was $8^{M}.5$, and June 12 and 13, $8^{M}.7$. June 20 it had fallen to $11^{M}.0$. These few observations suggest a maximum between June 7 and 10. It has since been observed on every clear night with the following results. It decreased very slowly from $11^{M}.0$ June 20, to $11^{M}.2$ Aug. 6. The rapid rise to maximum will appear from the following table, in which I have Mr. Sperra's permission to include his observation of Aug. 7.86, which limits the time of rise to 18 hours. The decimals of a day are in Greenwich mean time.

	M		M
Aug. 7.64	11.0	Aug. 10.58	8.5
7.86	11.0	11.60	8.6
8.60	8.8	12.58	8.7
8.90	8.6	13.58	9.0
9.58	8.6	14.58	9.3

The maximum is indicated for Aug. 10.5 at $8^{M}.5$. Aug. 19 it had fallen to $11^{M}.1$, and Aug. 20, 27 and 29 it was $11^{M}.2$. The intervals observed since last January, 62, 36, 42 and 62 days, respectively, make a curious succession, and suggest a "rotation of period." I have 18 observations in July and 18 in August.

8324. *V Cassiopeae.*

A minimum at $12^{M}.6$ is indicated for 1897 May 28, by 8 observations between May 3 and July 5. The magnitudes at the first and last dates were $12^{M}.0$ and $11^{M}.1$, respectively.

ON THE RECENTLY ANNOUNCED COMPANION OF *α LYRAE.*

In the August number of the *Astrophysical Journal* (p. 148) there is announced the discovery of a faint companion to *α Lyrae* with the Yerkes 40-inch telescope. The coordinates of the star are $S = 53''$ $p = 312°$. In 1881 I discovered, and Prof. Hall measured for me, a faint companion whose magnitude was estimated as 14.5. Its position was $S = 51''.48$ $p = 292°.9$ (see Washington Observations, 1888, page E 149). If this star is not still seen, there is little doubt that the companion of *α Lyrae* observed with the Yerkes telescope is the same one measured by Prof. Hall in 1881.

George Anderson,
Skilled Laborer.

U.S. Naval Observatory, 1897 *Aug.* 28.

EPHEMERIS OF COMET α 1897 (*D'ARREST'S*),

By G. LEVEAU (*A. N.* 3441).

Paris Midnight.

1897		α	Daily Motion	δ	Daily Motion	Br.
		h m s	s	° ′	′	
Sept.	6.5	4 22 48	+54	+1 57.3	− 9.3	0.19
	8.5	24 34	50	1 38.6	9.4	
	10.5	26 11	45	1 19.6	9.7	
	12.5	27 38	40	1 0.2	9.8	
	14.5	28 56	36	0 40.5	10.0	0.11
	16.5	30 5	31	0 20.5	10.1	
	18.5	31 4	25	+0 0.3	10.2	
	20.5	31 52	21	−0 20.1	10.3	
	22.5	32 31	16	0 40.7	10.3	0.17
	24.5	33 0	11	1 1.4	10.3	
	26.5	33 20	6	1 22.1	10.4	
	28.5	33 30	+ 1	1 42.8	10.4	
	30.5	33 29	− 4	2 3.5	10.3	0.17
Oct.	2.5	33 18	9	2 24.1	10.2	
	4.5	32 58	13	2 44.5	10.0	
	6.5	32 29	18	3 4.5	9.9	
	8.5	31 51	23	3 24.2	9.7	0.16
	10.5	31 3	27	3 43.6	9.5	
	12.5	30 6	32	4 2.5	9.3	
	14.5	29 0	36	4 20.9	9.0	
	16.5	4 27 46	−40	−4 38.7	− 8.7	0.15
Oct.	18.5	4 26 24	−44	−4 55.8	−8.3	
	20.5	24 54	48	5 12.1	7.9	
	22.5	23 17	51	5 27.6	7.5	
	24.5	21 34	54	5 42.3	7.0	0.14
	26.5	19 44	57	5 56.0	6.5	
	28.5	17 49	59	6 3.7	6.0	
	30.5	15 49	61	6 20.3	5.3	
Nov.	1.5	13 45	64	6 30.7	4.8	0.13
	3.5	11 37	65	6 40.0	4.2	
	5.5	9 27	66	6 48.0	3.6	
	7.5	7 14	67	6 54.8	3.0	
	9.5	5 0	67	7 0.4	2.3	0.11
	11.5	2 45	67	7 4.7	1.7	
	13.5	4 0 30	68	7 7.7	1.0	
	15.5	3 58 15	67	7 9.4	−0.4	
	17.5	56 2	66	7 9.9	+0.2	0.10
	19.5	53 50	65	7 9.2	0.8	
	21.5	51 41	64	7 7.2	1.4	
	23.5	49 35	−62	7 4.0	+2.0	
	25.5	3 47 33		−6 59.6		0.09

OBSERVATIONS OF THE PARTIAL SOLAR ECLIPSE, 1897 JULY 28,

MADE WITH THE 6-INCH REFRACTOR OF THE DETROIT OBSERVATORY, ANN ARBOR, MICH.,

By SIDNEY D. TOWNLEY.

[Communicated by the Director.]

	A. A. Mean Time		O—C	Power	Seeing
	h m s		s		
1st contact,	20 3 37		+1	80	Good
2d contact,	22 18 5	(perhaps)	−9	80	Unsteady
" "	22 18 10	(certain)	−4	80	"

The time of first contact is somewhat uncertain. The edge of the moon was first seen at 20h 3m 41s and was estimated to then be 4s past the sun's limb. The computed times were obtained from the formulae and data of the *American Ephemeris.*

The times that the moon's limb covered the large spot then visible upon the sun were recorded as follows: —

	h m s
Moon at edge of penumbra,	20 14 45
" " " " umbra,	20 15 7
" " second edge of umbra,	20 16 15
" " " " " penumbra,	20 16 53

The spot was about 14s from the western limb of the sun.

SOLAR ECLIPSE OF 1897 JULY 28,

By A. S. FLINT.

The sky was perfectly clear here for the eclipse of the sun July 28, and I observed it with the 40 cm. equatorial, and power 310. The observed times of contacts were 19h 36m 5s and 21h 43m 2s Central Standard mean time. The first time is corrected by an estimate, made at the moment, for late perception of the indentation. The last contact was little observed by the point of the sun's limb coming unexpectedly behind some coarse cross wires in the eyepiece, the driving clock not being employed. I watched the passage of the moon's limb over the large sunspot, but saw no change of note.

Washburn Observatory, Madison, Wis.

ON ANDERSON'S TWO NEW VARIABLES,

By J. A. PARKHURST.

In *A.N.* 3433, ANDERSON announced a star not in the DM., which he found $8^{\mathrm{M}}.8$, 1897 May 29 and June 8, but which was not seen, therefore less than $9^{\mathrm{M}}.5$ on July 9 and 10. He gives the place for 1855 as $12^{\mathrm{h}}\,23^{\mathrm{m}}.0$ $+32°\,17'$, approximately. On Aug. 1, I found an 11^{M} star close to this place, and measured its position relative to the two neighboring catalogue stars. It was $1^{\mathrm{m}}\,6^{\mathrm{s}}.9$ following and $6'\,40''$ north of DM. $+32°2250$ = Weisse's-Bessel XII. 460, and $48^{\mathrm{s}}.3$ preceding and $1'\,55''$ north of DM. $+32°2252$ = Lalande 23402–3. Its position is therefore

$$\text{R.A. } 12^{\mathrm{h}}\,23^{\mathrm{m}}\,1^{\mathrm{s}}\ ,\qquad \text{Decl. } +32°\,18'\,19''\quad(1855)$$
$$25\ \ 15\qquad\qquad\qquad 3\ \ 22\quad(1900)$$

There is an $11^{\mathrm{M}}.5$ star $9^{\mathrm{s}}.9$ following and $4'.4$ north of the variable. Aug. 1 the variable was half a magnitude brighter than this comparison star, and was equal or slightly fainter on Aug. 27.

Another star, in *Hercules*, was announced in *A.N.* 3440 as $9^{\mathrm{M}}.2$ on 1897 July 22 and 26, though invisible in the autumn of 1896, and not in the DM. I found it $9^{\mathrm{M}}.5$ on Aug. 23 and 24, and $9^{\mathrm{M}}.7$ on Aug. 27, using ANDERSON'S magnitudes for the comparison-stars. Its position, measured from ε *Herculis* (Frisby-Yarnall 7184, and Greenwich 12-year Catalogue) is

$$\text{R.A. } 16^{\mathrm{h}}\,55^{\mathrm{m}}\,1^{\mathrm{s}}.8\ ,\qquad \text{Decl. } +31°\,26'\,27''\quad(1855)$$
$$56\ \ 44.7\qquad\qquad\qquad 22\ \ 18\quad(1900)$$

There is no star as bright as the 12^{M} within less than $2'.5$ of the variable. The nearest stars are 10^{M} prec. 27^{s}, $1'.5$ N.; 12^{M} prec. 24^{s}, $0'.6$ N; 11^{M} foll. 10^{s}, $4'.1$ N; 12^{M} foll. 5^{s}, $2'.5$ S.

Marengo, Ill., 1897 *Aug.* 28.

NOTE ON THE PROPER MOTION OF BRADLEY 2725,

By J. G. PORTER.

Dr. AUWERS gives for the proper motion in right-ascension of this star $+0^{\mathrm{s}}.021$. This value has been adopted in the Poulkova Catalogue for 1855, and in the Bonn A.G. Catalogue, yet it seems to be entirely erroneous. The star was not observed by BRADLEY in right-ascension, and I am not aware what authorities Dr. AUWERS used in obtaining the proper motion.

As will be seen from the subjoined table the motion in both coordinates is extremely small. The positions are for 1900, and the corrections to the A.G. system as taken from Dr. AUWERS'S tables, have been applied.

Authority	Epoch	R.A. 1900	No. Obs.	Epoch	Decl. 1900
		h m s			° ′ ″
Bradley,	–	20 53 –	0, 1	1751.1	+48 48 39.6
Lalande,	1791.5	9.09	1	91.5	36.2
O. Argel.,	1842.6	9.76	1	1842.6	40.3
Poulkova	47.0	9.53	5	47.0	39.8
Armagh,	48.0	9.66	6, 5	44.4	41.2
Radcliffe 1,	48.3	9.64	3	48.4	38.0
Yarnall,	59.2	9.78	2, 6	54.0	38.7
Greenw. 9 yr.,	73.0	9.53	3	73.0	39.1
Bonn A.G.	81.3	9.45	2	81.3	39.0
Cincinnati,	96.6	9.67	3	96.6	39.0

Cincinnati, 1897 *Sept.* 6.

ON THE BINARY STAR β 395.

A telegram from Dr. SEE informs me that "binary β 395 revolves in 16 years; near periastron, 278°, 0″.2."

PERCIVAL LOWELL.

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FOUNDED BY B. A. GOULD.

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REASONS FOR THE ADOPTION OF NEW VALUES OF THE PRECESSIONAL MOTIONS; A REPLY TO THE REMARKS OF BOSS IN *A. J.* 410,

By SIMON NEWCOMB.

The remarks found in No. 410 of the *Astronomical Journal* are aimed so directly at certain proceedings in which the writer took part, that it seems desirable to make a reply at the earliest possible date. A reply is all the more necessary because it seems to the writer that Boss's remarks on the subject are not based on an adequate consideration of all the points involved. It may be suspected that a certain amount of misapprehension is caused by a defect of language. This defect consists in the use of the phrase "Constant of Precession," which leads to a feeling that the question is only that of the adoption of a certain value for a single quantity thus designated. I must therefore begin by repeating what I have said elsewhere, that there is no such thing as a "Constant of Precession" in this sense. True, we may take the motion of the equinox for the epoch 1850 or 1900 and apply this term to it. But in doing this we have by no means fixed all the data for reducing star-places from one epoch to another. We have annual precessions in declination and in right-ascension. In addition to these we have the trigonometric constants of reduction. As a fourth variable quautity we have the general precession, to be used in the reduction of longitudes. These four variable quantities depend on two motions, that of the equator and that of the ecliptic. Thus, what we are concerned with is not the adoption of a value for one quantity, but of numerical expressions for several varying quantities.

I take as the basis of what I have to say on the subject the desideratum mentioned by Boss on page 12. One of the great needs of astronomy at the present time is a standard catalogue embracing as large a number of stars as possible. This work requires at least two kinds of researches. One class embraces the reduction of the older observations with our improved modern data, the other a wide range of investigations on the relative positions of stars at the present time. Both these classes of work should be conducted on the same homogeneous basis. A great deal of reduction of mean places of stars from one epoch to another will be necessary. The intervals of reduction may very soon extend to 150 years. The precessional motions employed in these reductions should fulfil the following conditions:

First, They should be as nearly as possible correct, else misleading conclusions respecting proper motions, especially the laws of proper motion, may result.

Second, The four motions in question must be as far as possible theoretically self-consistent within 0".01 per century. In other words, the astronomer who reduces the position of a star from 1755 to 1900 must get the same result whether he uses trigonometric constants, mechanical integration by annual precession at various epochs, or reductions in longitude. This degree of precision is necessary, not because we expect actually to attain it in our practical work, but because with this degree of numerical accuracy it is more easy to detect discrepancies and obtain reliable results.

Although Professor Boss does not distinctly say so, he seems to imply that STRUVE's precessional motions should be employed. I must therefore point out that these motions do not satisfy either of the above conditions. As compared with the equinox of the *Astronomische Gesellschaft* the error in the motion would be more than two seconds per century. Even with the new equinox it would be so great as to impair general conclusions respecting proper motions. An unfortunate confusion has arisen in the use of the STRUVE constants from the fact that the planetary precession has not been made strictly correspondent to the motion of the ecliptic. I have not investigated the question whether it would be possible to assign such motions to the equator and to the ecliptic that the STRUVE–PETERS values of all four of the above named variable quantities should be simultaneously represented. It is certain that if we should assume such motions they would not be accordant with the best existing theory, or with the probable truth, but would be purely empirical in their nature.

Under these circumstances it seems to me that the conclusion of the Conference to adopt an improved value of the precessional motion was fully justified. If this is not done, astronomers will be under the constant necessity of using provisionally corrected values of the precession, as Auwers has done in the introduction to his Berlin Catalogue.

I now pass to the consideration of certain objections set forth by Boss in his last paragraph on page 10, to the definitive character of my result. Here, as well as on page 9, he shows with great correctness and clearness that, in order to reach a definitive value of the precessional motion, the proper motions employed must be as free as possible from those systematic errors which might influence the result, and must therefore depend, not on a comparison of two catalogues, but on the best possible determination of the proper motions from all authorities. What he does not see is that, in substance if not in form, my result does depend on all the existing authorities which can add to the strength of a system of declinations. I too hastily assumed that it would be taken for granted that I aimed at a result as nearly definitive as the present state of the case would admit of, and therefore did not set forth with sufficient fulness, either in my extended paper, or in the brief abstract in the *Astronomical Journal*, the reasons on which this claim might be based. Even here I can submit only a summary outline of those reasons. The right-ascensions and declinations have to be considered separately, because the systematic errors to which they are liable are quite different in form.

First of all we must depend mainly upon the Bradley stars. It needs no argument to show that the proper motions of these stars, taken individually, are far better determined than are those of the great mass of fainter stars, especially when freedom from systematic error is considered. In determining the precession from observations of the fainter stars in right-ascension we meet with the insuperable difficulty that they are vitiated by variation of personal equation with magnitude. We know nothing about the numerical value of this quantity in the case of any but a few recent series of observations, where we find it to be surprisingly large. In the case of the older observations it can only be brought out by systematic differences between the proper motions in right-ascension of the faint stars and those of the bright stars. It follows that when we attempt to determine the constant of precession from observed proper motions of faint stars what we really obtain is not the constant of precession, but rather the difference between the personal equation of the two sets of observers compared. It is therefore not possible to derive a reliable value of the precessional motion in this way. It must not be forgotten that this difficulty has another superposed upon it, the fact that all the older zone catalogues are reduced by data which can very well be affected by large systematic errors.

In the case of the declinations, there is but one form of systematic error which is not eliminated from the precessional motion derived from stars scattered uniformly around any zone of the celestial sphere. This systematic error in the proper motions is of the form

$$\Delta\delta_\alpha = k \cos\alpha$$

Now, I showed in the *A.J.*, Volume XVI, p. 35, that the Boss proper motions in declination appeared to be, so far as modern observations could show, free from any appreciable error of this form. Hence, in order to free the proper motions of Auwers-Bradley from any error of this form, it was only necessary to reduce them to the Boss system. It has of course to be shown that there is no appreciable difference between Auwers's modern system and that of Boss so far as this term is concerned. A comparison of Auwers-Bradley with Boss showed that the value of the coefficient k in the above expression changed with the declination, being sometimes negative, and sometimes positive. The mean result of the correction was to change the centennial motion of the pole by about 0″.06. On comparing the results from different zones the discordances between the zones was found to be increased by the supposed reduction to the Boss system, although the final result was, as just mentioned, not strikingly altered. The reality of the corrections for reduction to the Boss system is therefore subject to grave doubt. I attribute the discrepancy less to errors of either set of declinations than to the accumulation of accidental differences in the case of individual stars. This conclusion illustrates the danger of concluding that a mean difference between the coordinates of two catalogues indicates a systematic difference, unless the number of stars of comparison is considerable.

After the work was done, I applied yet another test to determine whether Auwers's proper motions are affected by any such error. In my new fundamental catalogue about 800 stars are common to that catalogue and to Auwers-Bradley. This number is amply sufficient to detect a systematic difference of the form in question. A comparison is found on p. 57 of my paper, which shows that the coefficient k in the expression of the difference between the two systems would be only 0″.03. I conclude, therefore, that the result derived by the adopted method is better than any that could be obtained by including other authorities than those employed. Practically, if not formally, all valuable authorities are used. Another circumstance strengthens the general conclusion thus reached. It may be objected that the number of stars employed is so small, only about 2000 having much weight, that the effect of accidental proper motions may be appreciable. I shall presently show that the effect of this cause is less than would have been supposed.

The general certainty of the result attained is enhanced by the remarkable conclusion derivable from the researches of both Kapteyn and myself on the distribution of proper motions in magnitude. This conclusion is that the *motus peculiaris* of an unexpected proportion of the Bradley stars is very small, less, indeed, than $1''$ per century. It is not easy to select these stars individually, but their number is probably more than one-third, and possibly one-half that of the whole number of the fourth and higher magnitudes contained in Auwers-Bradley.

The case may now be summed up as follows. Were the proper motions in declination of a vast number of stars, say all those of the *Durchmusterung*, accurately known, the probable error of the resulting value of n might be regarded as *nil*. The actual number of stars available being limited we have a probable error arising from the dispersion of the proper motions of these stars, regarded as the results of chance deviation. With this is to be combined the accidental errors of the determinations of the separate stars. In the case of the stars actually used the combined effect is equivalent to a probable error of about $\pm 2''.0$. The weight of $100\,n$ is about 500, so we may estimate the accidental probable error of $100\,n$ as $2''.0 \div \sqrt{500} = \pm 0''.09$. With this must be combined the probable value of the systematic error k. For this we have three tests, the agreement of Auwers's motions with the new systems; and the accordance of results derived from different zones of declination as found in *A.J.*, page 164, would indicate a probable error smaller than $\pm 0''.10$. I can only attribute the remarkable accordance here shown to accident.

Altogether I think that the probable error of the motion of the pole which I have derived is not likely to exceed $\pm 0''.15$ per century. The corresponding error in the motion of the equinox would be $\pm 0''.38$. But to this must be adjoined the uncertainty as to the motion of the equinox itself among the stars. I do not think it will be possible to make the probable error materially smaller until we have at command the results of observations and researches not likely to be available for thirty or perhaps fifty years. As an aid to the necessary researches the best available value of the precessional motion is, as already shown, required in advance. Hence, one *raison d'être* for the discussion under consideration.

In saying this, I expressly disclaim any expression of opinion on the question whether the action of the Conference of 1896 in adopting in advance the new values of the precessional motion was wise. Professor Boss impugns the wisdom; I leave the conclusion to others.

ON A FUNDAMENTAL OPTICAL DEFECT IN THE IMAGES FORMED BY A PARABOLIC REFLECTOR,

By J. M. SCHAEBERLE.

In the present paper, which is to be regarded as supplementary to the article in No. 364 of this *Journal*, I propose to demonstrate that there exists a fundamental, theoretical optical defect in the images formed by a parabolic reflector and that, except for certain spectroscopic, bolometric or similar work, this defect destroys the efficient use of large mirrors of short focal length for making delicate observations.

Until quite recently the largest reflector I had ever tested was one of 18 inches aperture, having a focal length of 148 inches. This is now used as a Cassegrain telescope for photograph work; the equivalent focal lengths employed varying from about 80 feet to about 800 feet. As specimens of the results obtained, the reader is referred to the forthcoming number (No. 58) of the "Publications of the Astronomical Society of the Pacific," which will contain three silver prints of the planet *Jupiter* made from the focal negatives,* the equivalent focal length being 650 feet.

On a very favorable night, I recently had the opportunity of testing the great Crossley reflector of the Lick Observatory and found the surface of the same to be a practically perfect paraboloid of revolution; but on examining certain celestial objects — *Saturn* among others — I was very much surprised to find that the instrument failed most signally to come up to expectations. While puzzling and pondering over the probable cause of the poor results given by what I knew to be a finely figured surface, it occurred to me to ascertain the exact amount of the error introduced in the form of the image, resulting from the well known fact that the focal point is not at the center of curvature of the parabolic mirror.

If we imagine that a small circular disk, placed in the focal plane of a paraboloid of revolution concentric with the optical axis, is viewed from different points in the surface of the mirror, the form of the disk will not only appear to vary from a circle, on the optical axis, to an ellipse of increasing eccentricity as the distance of the eye from the optical axis increases, but the angular diameter of both axes of this ellipse will decrease, owing to the increasing distance of the eye from the focal point.

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*As this particular instrument is intended to be used only for planetary photography, in which the maximum angular area to be dealt with is only about $1'$, I shall, in view of the theoretical results established in this paper, re-grind and re-figure the 18-inch reflector at the earliest opportunity, and make the ratio of focal length to aperture 18 to 1 instead of 8 to 1, the present relation.

This change will reduce the factor from 1.0028 to 1.0005. Assuming a maximum error of $6'$ in the adjustment of the image with reference to the optical axis, the blurring will be reduced from $360'' \times 1.0028 = 1''.00$ to $360'' \times 1.0005 = 0''.18$; while the minimum blurring for a radius of, say, $30''$ from the optical axis, will be reduced from $0''.08$ to $0''.03$.

For the Crossley telescope an error of only $6'$ in the adjustment of the image will cause a blurring of $360'' \times 1.0057 = 2''.05$.

It, therefore, follows that when the angle at every point in the mirror's surface is constant, as is the case for rays of light coming from any two points on the celestial sphere which are reflected by the mirror, the *linear* distance between the focal images of these two points, as formed by reflection from different areas along any radius of the mirror, will vary from a minimum for the area on the optical axis to a maximum for the area most distant from this axis.

I find* that Dr. Hugo Schroeder, in considering some of the chief causes which, in his opinion, account for the observed fact that the reflector is inferior to the refractor, also incidentally mentions, as a secondary cause, the fact that the outer areas give larger images than the more central parts of the mirror.

The theoretical investigations which follow are confined to the field of geometrical optics.

Let R denote the radius of any ring of the parabolic reflecting surface which is concentric with the optical axis.

Let ρ denote the distance from the focal point to any point in the circumference of the ring.

Let $2v$ denote the angle subtended by a diameter of this ring at the focus.

Let F denote the focal distance; viz., the distance from the focus to the mirror, measured on the optical axis. Then

$$\text{(1)} \qquad \sin v = \frac{F}{\rho}$$

From the polar equation of the parabola we have

$$\text{(2)} \qquad \rho = \frac{F}{\cos^2 \frac{1}{2} v}$$

Eliminating ρ from equations (1) and (2) we find

$$\text{(3)} \qquad \frac{F}{R} = \frac{\cos^2 \frac{1}{2} v}{\sin v}$$

From which v can be found for any given values of R and F.

Now, let the small angular diameter of a celestial object, whose outline is circular, and whose center coincides with the optical axis of the parabolic reflector, be 2θ. The linear radius, r, of the cone of rays reflected from a point in the optical axis of the mirror, at the distance F from the vertex of the cone will be

$$\text{(4)} \qquad r = F \sin \theta$$

To find the linear radius of the image formed by reflection from the ring of the reflecting surface whose radius is R, let us first consider the cone of rays reflected from a single point in the circumference of this ring. The linear radius r' of this cone at the distance ρ from the vertex will evidently be given by

$$r' = \rho \sin \theta = \frac{F \sin \theta}{\cos^2 \frac{1}{2} v} \qquad (5)$$

The intersection of this cone by a similar cone of rays reflected from the diametrically opposite point in the circumference of the same ring will be an elliptical area whose center is coincident with the focal point, and whose semi-major and semi-minor axes (a and b) are given by the approximate expressions

$$a = \rho \frac{\sin \theta}{\cos v} = \frac{F \sin \theta}{\cos v \cos^2 \frac{1}{2} v} \qquad (6)$$

$$b = r' = \frac{F \sin \theta}{\cos^2 \frac{1}{2} v} \qquad (7)$$

The intersections of all the cones of light rays reflected from all the points in the whole circumference will therefore result in a circular image whose extreme diameter is a, gradually increasing in brightness for a decreasing radius, for the short distance $a-b$ leaving a central area, of radius b, of uniform brightness.

The radius of the image formed by reflection from the ring divided by the radius of the image formed by the central part of the mirror at the distance F from the surface is, therefore,

$$\frac{a}{r} = \frac{1}{\cos v \cos^2 \frac{1}{2} v} \qquad (8)$$

an expression which shows that this ratio is dependent only on the angular aperture of the reflecting surface and that for increasing values of v the magnitude of the ratio increases.

As each change in the value of R causes a corresponding change in v, and hence also in a, it follows that the image formed by reflection from the whole surface is made up of an infinite number of images having diameters which increase from $2r$ to $2a$.

For the extreme case when $v = 90°$, no *image* of an area can be formed by reflection from a ring of the mirror, as the only intersections in the focal plane are those at the focal point.*

With the aid of the foregoing formulas we will now compare the efficiency, so far as definition is concerned, of the more modern reflectors.

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* See July number of "*Sirius*," page 161, lines 30 to 33.

* In this connection it is interesting to note that for the Cassegrain form of telescope, *and for this form only*, the focus of the parabolic reflector can be made so short that even for v much greater than 90° practically all the *stellar* light intercepted by this mirror can be utilized, provided the focus of the secondary hyperbolic reflector is extremely short, so that only a small amount of direct light is intercepted by the secondary. Such an instrument would, however, only be suitable for, say spectroscopic, bolometric or similar work.

Reflector	Diamet. of Mirror $= 2Rm$	Focal Length $= F$	Max. Ratio of Diameters $= \frac{a}{r}$	Diff. of Angular Diameters for the given ratio	
				Saturn's Outer Ring	Sun or Moon
	feet	feet		″	″
Lord Rosse	6.0	55.0	1.0033	0.13	6
Common	5.0	27.0	1.0077	0.31	14
Lassell	4.0	37.0	1.0022	0.09	5
Melbourne	4.0	28.0	1.0039	0.16	7
Paris	3.9	23.4	1.0051	0.20	9
Crossley	3.0	17.3	1.0057	0.23	10
Draper	2.4	13.0	1.0064	0.26	12
Lassell	2.0	20.0	1.0019	0.08	3
Roberts	1.7	8.2	1.0078	0.31	14
Common	1.7	3.7	1.0404	1.62	73
Schaeberle	1.5	12.3	1.0028	0.11	5
Draper	1.3	13.0	1.0019	0.08	3
Schaeberle	1.0	3.7	1.0141	0.56	25

The column containing the values of $\frac{a}{r}$ give, for each instrument, the factor by which the diameter of the image formed by the central area must be multiplied in order to equal the diameter of the image formed by reflection from the outermost zone of the particular mirror.

While the extreme difference between these angular diameters of the same object remains practically constant for any part of the field of view, the blurring effect, caused by the overlapping images, will be even greater than the extreme difference in the diameters whenever the distance from the optical axis is greater than the diameter of the image.

Aside from distortional effects due to distance of the image from the optical axis, each star image will appear brightest at its center, and increase in size along a line drawn from the optical center as its distance from the optical axis increases.

In the case of a double star the factor $\frac{a}{r}$ for each instrument is the ratio of the maximum and minimum distance between the two components according as the reflections corresponding to the extreme positions of the images take place at the outermost or central areas of the mirror.

All distances measured from the optical axis with a parabolic reflector are theoretically too large,* and practically so for nearly all of the instruments mentioned in this paper whenever the distance measured exceeds, say, 10″. In all cases the measures should be made only a few seconds of arc from the optical axis.

An inspection of the figures given in the last two columns of the foregoing table at once makes it evident that all of the instruments considered form sensibly overlapping images, even for the planet *Saturn*, on the optical axis. The Lassell and Draper instruments, owing to their relatively great focal length, being most free from this error. With the former instrument, it will be remembered, were discovered the satellite of *Neptune*, the two inner satellites of *Uranus* and the faintest satellite of *Saturn*; while with the latter instrument have been obtained probably the best photographs of the Moon taken with a reflecting telescope.

The figures in the last two columns are those resulting from the best possible conditions. For instance, we wish to examine the Cassini-division of *Saturn's* ring. By bringing one extremity of this division exactly in the optical axis, no theoretical (geometrical) defects would be present in this point of the image, but at the opposite point of the ring a want of good definition would be noticed; the amount of the blurring for the different telescopes mentioned are given in the next to the last column. As the width of the Cassini-division is less than half a second of arc, at least two of these telescopes would only show the division as a semi-dark marking in the ring-system, the whole width of the division being flooded with light from the overlapping images. If a point on the Moon's circumference and in the optical axis is under examination the outline of the Moon's image at the other extremity of the diameter will be blurred to the extent shown by the figures given in the last column, aside from the purely distortional effect also produced.*

---

*It is here assumed that the standard distance for measuring the angle is the focal length F of the particular telescope.

* To show that the distortion *as ordinarily regarded* plays only a minor part in the cause of the variations here considered, let us imagine that a perfect lens whose *theoretical* surface is of 60 inches aperture and 324 inches focal length is to be compared with Mr. COMMON'S great parabolic reflector having these same constants. Let the focal image be 0.1-inch from the optical axis in each case, corresponding to an angle of 64″. The distortion may then be regarded as a function of the difference between the lengths of two lines, in a plane with the optical axis, drawn to the extremities of a diameter of the lens or mirror. A simple computation gives, for the lens

Nearer extremity of diameter,	323.99 inches
Farther, " " "	324.01 "
Difference,	0.02 "

and for the paraboloid,

Nearer extremity of diameter,	324.79 inches
Farther, " " "	324.81 "
Difference,	0.02 "

Now, since the distance from the focus to the center of the mirror is only 324.00 inches, we see that in this case the difference between the distance from the focus to the center of the mirror, and the distance from the focus to the edge of the mirror is 40 times as great as the function on which the distortion, *as ordinarily considered*, depends.

For the first case the two focal points of the small surface-areas at the extremities of the diameter of the lens will lie on opposite sides of the focal plane and at different distances from the optical axis. All the other focal points corresponding to other elementary areas of the lens will lie along a line joining these two points. In the case of the parabolic mirror every image formed by any concentric ring-surface element of the mirror may be regarded to be of a practically perfect outline, disregarding, for the present, the penumbral boundary whose width is $(a - b)$ insensibly elongated and situated in the principal focal plane. The images will be arranged along a line drawn from the optical axis, and increase in size as the distance from the optical axis increases.

From these theoretical considerations it is therefore evident that if a good defining power is desired, the ratio of focal length to aperture should never be less than, say, 14 to 1.

The exact position of the point, in the field of view, through which the optical axis passes should be known. [See Note No. 1.] The radius of the field of measured distances with the optical axis as a center, should then not exceed the value which introduces an error of more than, say, 0″.05. With this condition fulfilled the limiting radius of the field of view of best definition for each telescope named in the table and in the order given, would be as follows:

15″, 7″, 22″, 13″, 9″, 9″, 8″, 25″, 6″, 1″, 19″, 25″, 4″.

As even the most carefully mounted mirror is liable to shift through a much larger angle for different pointings of the telescope, a convenient and rapid method of finding the optical axis should be used if the best possible results are desired.

While the present investigation has been confined to the field of geometrical optics, it seems practically certain that there are no laws of physical optics which can operate in such a way as to correct the defects in the images of even the smallest areas formed by a perfect paraboloid of revolution.

In conclusion, it seems surprising that the exact determination of the errors in the focal images due to the varying distance from the focus to the various points on the reflecting surface, has apparently never been made, when in fact these errors alone satisfactorily demonstrate that a large parabolic reflector having a ratio of focal length to aperture which is less than, say, fourteen to one, is theoretically and practically, unfit for making observations of extreme delicacy.

Lick Observatory, University of California, 1897 *Sept.* 10.

CONFIRMATION OF VARIABILITY,*

By J. A. PARKHURST.

I have secured the following observations of Anderson's new variable in *Hercules* at $16^h\ 55^m$, +31° 26′ (1855). Having revised my light-scale I give the improved values for the whole series.

The light-scale depends on thirty comparisons on the eight evenings.

Observations.

	M		M
1897 Aug. 23	9.5	1897 Aug. 30	10.3
24	9.7	Sept. 3	10.4
27	9.9	7	10.6
29	10.2	12	11.1

ON THE NATURE OF THE LIGHT-VARIATIONS OF 3407 *S ANTLIAE*,

By WM. E. SPERRA.

The variability of this star was announced (*Ast. Jour.*, IX, p. 180) by Paul in 1888; it was then confirmed by Sawyer (*Id.*, p. 183), who stated that its variation was of the *Algol*-type; Chandler (*Id.*, p. 190) confirmed the *Algol*-type; then followed Yendell (*Id.*, vol. X, p. 11) giving a further confirmation of the *Algol*-type nature of its variation.

Under date of 1896 June 5, Harvard College Observatory issued their Circular No. 7, and in it appears the following paragraph alluding to the type of variation of this star:

"A large number of observations have been made with the meridian photometer to determine the forms of light-curve of stars of the *Algol*-type. *S Antliae* has been hitherto regarded as belonging to this class, and is of interest from the shortness of its period, $7^h\ 46^m.8$, and since it was said to retain its full brightness for less than half of the time. It is difficult to reconcile the last condition with the theory that the variation is due to a dark eclipsing body. One hundred and seventy-seven measures, each containing sixteen photometric settings on *S Antliae* were made with the meridian photometer, and give eight normal points. A smooth curve with only two points of inflection can be drawn through these normal points, the greatest deviation being $0^M.02$. From this it appears that *S Antliae* is not a star of the *Algol*-type, that its light is continually changing, and that it belongs to the class of variables of short period, like *δ Cephei* and *η Aquilae*. An interesting feature of this curve is that the time of increase occupies 0.62 of the entire time of variation, the increase of light being slower than the diminution."

Upon the assumption that it was of the *Algol*-type, I commenced observing the star in the Spring of 1895, and observed it seventy-two times on six nights, when the above circular came to my notice. My resulting minima are given below. The times are heliocentric local mean time, which is about $5^h\ 23^m$ slower than that of Greenwich. The column O—C gives the residuals from a comparison with Chandler's elements. The times are from a single curve.

---

* In consequence of the above confirmation the definitive notation is thus assigned: 6100 *RV Herculis*; (1855) $16^h\ 55^m\ 2^s$, +31° 26′.4; (1900) $16^h\ 56^m\ 45^s$, +31° 22′.3. — Ed.

		Observations	O—C
1895 March 18	$10^h\ 52^m$	17	-41^m
21	8 40	10	−30
22	8 20	10	−50
April 2	8 30	15	−28
1896 April 4	8 30	7	−60

When the Harvard Circular appeared it was decided to change the method of observation of the star, and instead of observing for the minimum only, observations were commenced without any reference to the computed time of minimum, and as many observations were obtained each clear night as circumstances permitted. In this manner the observations were unaffected by any previous knowledge of what the star should appear like, or should do. From 1896 October 25 to 1897 May 16, one hundred and twenty-two additional observations were obtained on thirty-two nights, making a total of one hundred and ninety-four observations in all. By means of the elements in Chandler's Third Catalogue these observations were collected into half-hourly groups, and fifteen normal points for a mean light-curve were obtained. In the table are given readings from the curve passing through these points. The phase of the points is reckoned from the minimum or lowest point of the curve. The value of my light-step in the scale given at the close of this paper is 0.046 of a magnitude.

Readings from the Mean Light-Curve.

Time after minimum	Light	Time after minimum	Light
$0^h\ 0^m$	7.4	$3^h\ 48^m$ (Max.)	16.0
0 30	8.3	4 0	16.0
1 0	10.5	4 30	15.8
1 30	12.8	5 0	15.3
2 0	14.4	5 30	14.6
2 30	15.2	6 0	13.3
3 0	15.7	6 30	12.2
3 30	15.9	7 0	9.7
		7 30	7.7

From the readings of the curve it will be noticed that the light of the star is continually changing, though for about two hours on either side of maximum the change is very slow, amounting to only two light-steps, or 0.1 magnitude. The interval from minimum light to maximum is 0.49 of the entire period.

With but two exceptions all the observed lights making up the nine groups for normals near the maximum part of the curve, differ but little from the mean of the group, while the remaining six near minimum have high and low lights thrown into them. The curve is, therefore, quite satisfactory near maximum, but very indecisive at minimum. The difference of light in some groups amounts to eight or nine steps, or about two-thirds the light-range of the star; the greatest range of light between maximum and minimum that I have noted being about twelve steps.

The difference in light of some of the observations in the groups seems to be too great to be attributable to errors of observations, and besides is of too frequent occurrence to be assignable to any such cause. That what is meant may be evident to all, the accompanying table, giving the observed lights grouped according to the computed phase, and showing the observations that fall under any one night's work, is given. The mean time for each group is at the head of each column of lights, and the mean light for the group is at the bottom of same. The point of reference for the times of each group is the computed time of minimum by Chandler's elements, and all the groups have been reckoned as after minimum.

A study of the observations on nights when minima, or portions thereof were observed, would seem to indicate that the mixing of high and low lights in the groups for normals, arises from two causes, viz.: that the form of curve at minimum seems not to be constant at different minima, but that the decrease is often much more rapid than the increase, and *vice versa*, and at other times both are nearly equal; and secondly, an oscillation of the time of minimum with respect to the time of the maximum phase which is constant. However, of these two apparent causes I would at present speak but modestly, as other causes might conspire to cause the discrepancy; but as the meridian altitude of the star is small, the hour-angle complication is not to be reckoned with, and it does not seem that it could be altogether due to absorption, as the color of the star is white (Chandler's Catalogue). It might be of interest to investigate this point further when more observations are at hand.

As previously stated the change of light for nearly four hours at the maximum phase is so slow, and the range so slight, that with the average value of the light-step of most observers, viz., 0.1 magnitude, this part of the curve would be practically flat, giving the impression that it was of the *Algol*-type; though the nearly equal times consumed in the light-change of minimum, and the nearly stationary light at maximum, would indicate that the cause of the light-variation is due to an entirely different cause than that of an eclipsing body, as in the case of *Algol*.

The comparison-stars used, with their light and magnitude (Sawyer), are given below. The numbers are from the *Uranometria Argentina*.

Star	Name	M	Light st.
a	66 *Pyxidis*,	6.5	19.8
b	7 *Antliae*,	7.0	9.4
c	5 *Antliae*,	7.4	0.0

TABLE OF OBSERVATIONS FOR NORMALS GROUPED ACCORDING TO COMPUTED PHASE AND DATE OF OBSERVATION.

		$0^h0^m.2$	$0^h25^m.0$	$1^h2^m.0$	$1^h31^m.0$	$1^h56^m.0$	$2^h29^m.2$	$3^h2^m.9$	$3^h43^m.1$	$4^h17^m.3$	$4^h46^m.9$	$5^h21^m.3$	$5^h48^m.4$	$6^h15^m.1$	$6^h48^m.3$	$7^h19^m.7$
1895 Mar.	18	5.8	5.2 5.2	4.7 5.2	6.4	7.2 9.4	12.6	13.9	. .	. .	. .	15.4	13.6	14.2	12.6 9.4	7.2 6.4
	21	6.2	5.0	5.7 6.7	12.6	13.6 14.1	14.1	. .	. .	. .	. .	. .	. .	. .	13.4	6.9
	22	13.1 12.6	6.2	5.7 5.9	7.5 7.2	9.4 12.6	13.4	. .	. .	. .	. .	. .	. .	. .	. .	. .
	24	. .	. .	4.7 5.2	5.2 6.2	12.1 13.6	14.1	15.6 14.6	14.6	. .	. .	. .	. .	. .	. .	. .
1895 Apr.	2	5.9 5.2	5.0 4.7 5.2	5.9 6.2	6.7	8.2 10.4	12.1 13.1	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	13.6 6.7
1896 Apr.	14	. .	6.4 5.7	5.2	6.4	6.9 7.4	11.9	. .	. .	. .	. .	. .	. .	. .	. .	. .
1896 Oct.	25	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	14.3	. .	. .	. .	. .
	26	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	14.8	. .	. .
1896 Nov.	1	. .	. .	. .	. .	. .	14.8	. .	. .	. .	. .	. .	. .	. .	. .	. .
	15	. .	. .	. .	. .	. .	14.1	13.9	. .	. .	. .	. .	. .	. .	. .	. .
	22	. .	12.6	14.1	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	29	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	16.4	. .	. .	. .	. .
	30	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	15.6	. .	14.6	13.6
1896 Dec.	1	12.6	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	15.1	13.6	13.6
	27	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	13.3	. .
1897 Feb.	24	13.1	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	14.1	14.1
	27	. .	. .	13.4	. .	12.6	13.6	. .	. .	. .	. .	. .	. .	. .	. .	. .
1897 Mar.	7	7.4	12.4	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	10	13.1	11.4	. .	12.4	13.1	14.1	15.1	15.8	16.4	16.4	16.4	15.1	. .	. .	. .
	11	. .	. .	. .	. .	. .	14.1	13.9	14.1	16.3	15.4	14.8	15.4	14.6	. .	. .
	15	. .	. .	. .	. .	. .	. .	13.9	15.8 16.1	16.3	15.6	15.8	16.3	14.8	15.1	14.1
	16	12.6	. .	. .	. .	. .	. .	. .	14.8	16.1	16.6 16.1	16.6	. .	16.6	15.6	13.4
	20	. .	7.4	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	21	. .	8.4	6.9	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	11.9	10.4
	28	12.9	. .	. .	. .	. .	. .	. .	15.3	15.8	16.1	15.9	16.3	15.6	14.4	15.1
	30	12.4 7.9	9.4	. .	. .	. .	. .	. .	. .	. .	. .	15.3	. .	14.1	13.9	13.1
	31	12.2	. .	8.4	. .	. .	. .	. .	. .	. .	. .	. .	. .	15.1	12.8	13.2
1897 Apr.	10	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	15.6	15.8	. .	. .	. .
	17	. .	. .	. .	. .	. .	16.3	. .	16.3 16.6	17.1	16.3	. .	. .	. .	. .	. .
	20	. .	. .	. .	. .	. .	. .	. .	15.6	15.3	15.6	15.3	14.6	14.6	. .	. .
	24	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	11.4
	27	. .	. .	. .	12.6 12.6	13.6	14.6	. .	. .	. .	. .	. .	. .	. .	. .	. .
1897 May	5	13.9	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	14.4	13.1
	7	13.1	11.6	11.4	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	8	. .	12.3	13.6	15.8	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	10	. .	. .	. .	. .	. .	15.1	. .	. .	. .	. .	. .	. .	. .	. .	. .
	13	. .	. .	. .	. .	. .	. .	. .	16.3	. .	. .	. .	. .	. .	. .	. .
	15	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	15.6	16.1	16.4	. .	. .
	16	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	14.1	15.4	14.9	. .
Mean		10.6	7.9	7.7	9.3	11.1	13.9	14.6	15.6	15.9	16.0	15.6	15.3	15.1	12.8	11.6

Randolph, Ohio, 1897 *Sept.* 8.

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ON THE EFFECT OF THE SIZE OF AN OBJECTIVE ON THE VISIBILITY OF LINEAR MARKINGS ON THE PLANETS,

By F. L. O. WADSWORTH.

In the discussion of the relative advantages of telescopes of large and of small apertures for observing planetary markings in the nature of fine lines, such as the linear markings* on *Mars*, there is one point of considerable importance which is generally either completely lost sight of, or worse yet, mis-stated. In the latter case the error arises from making use of the principles of geometrical rather than of physical optics, a procedure that invariably leads one to erroneous conclusions when it is a question of determining the intensity or character of the images, on the one hand of fine points or lines, or on the other of the general illumination of the field due to extended luminous areas of nearly uniform intensity, such as a starlit, or, under certain conditions, a moonlit or sunlit sky.

Thus in a recent publication the statement was made that the intensity, i, of the image of a fine line varied as $\frac{b^2}{f}$, b and f being respectively the aperture and focal length of the image-forming lens. Then since the intensity $i_{\prime\prime}$ of an image of a surface of finite size varies as $\frac{b^2}{f^2}$ it would follow at once from the above assumption that the distinctness of a fine line of intensity k, projected on a surface of intensity $k_{\prime\prime}$ would be proportional to

$$(1)\qquad \text{Contrast between two images} = K = \frac{i+i_{\prime\prime}}{i_{\prime\prime}} = 1 + \frac{i}{i_{\prime\prime}}$$

$$(2)\qquad \therefore K - 1 = \frac{k}{k_{\prime\prime}}\,\frac{\frac{b^2}{f}}{\frac{b^2}{f^2}} = \frac{k}{k_{\prime\prime}}f$$

or the distinctness of fine lines on a uniform surface, such as rills and veins on the surface of the Moon or linear markings on the surface of *Mars*, will be independent of the aperture, and will vary simply as the focal length of the telescope. It would hardly seem necessary to point out at this time (when the principles of the wave-theory have been commonly accepted and taught for nearly a century) that such a conclusion is entirely wrong. Yet, so far as the writer has been able to determine, it has so far been allowed to pass unchallenged.

In a recent paper dealing with the general theory of the images of different forms of radiating sources,* it has been shown that the intensity at the center of an image of a fine line of limited length is represented by

$$i = \frac{2}{3}\,k\,\frac{b^3}{\lambda f^2} = \text{const.}\,k\,.\,\beta^2.\,b \qquad (3)$$

The intensity of an image of a uniformly luminous surface of finite extent, for all points not near the edge of the geometrical image (such as the central portion of the surface of a planet), is

$$i_{\prime\prime} = k_{\prime\prime}\,\frac{\pi b^2}{4f^2} = \text{const.}\,k_{\prime\prime}\,.\,\beta^2 \qquad (4)$$

The contrast between the image of the line (at the center) and the image of the surface on which it is projected is therefore

$$K = 1 + \frac{8}{3}\cdot\frac{k}{k_{\prime\prime}}\cdot\frac{b}{\pi\lambda} \qquad (5)$$

or, instead of the contrast varying as the focal length, as it would according to the principles of geometrical optics, it really varies directly as the linear aperture of the telescope, and is independent of the focal length of the latter. That is, a line of given intensity, k, as seen projected against a surface of uniform intensity $k_{\prime\prime}$ in a telescope of given aperture $b_{\prime}$, would, optical conditions being perfect, appear twice as bright (or dark, according as k is greater or less than $k_{\prime\prime}$), when viewed through an aperture $2b_{\prime}$, three times as bright through an aperture $3b_{\prime}$, etc., and lines which, on account of the small difference between k and $k_{\prime\prime}$ could not be seen at all through an aperture $b_{\prime}$, might be made out with an aperture $2b_{\prime}$, and easily seen through an aperture $3b_{\prime}$. Or, to put it in another more definite way, the linear markings on *Mars* first observed by SCHIAPARELLI in 1877 with an $8\frac{3}{4}$-inch aperture ought, under perfect conditions, to be nearly three times as distinct with a 24-inch aperture, and over four times as distinct when seen through the 36-inch aperture of the Lick telescope.

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* The writer suggests the term linear markings in place of the usual designation "canals," as indicating all that the word *canali* of SCHIAPARELLI was originally meant to express, without conveying the idea of artificiality which has been unwarrantably ascribed to them by more recent writers.

* "On the Conditions of Maximum Efficiency in Astrophotographic Work." Part I. General Theory, *Astrophysical Journal*, August, 1897.

There is, however, an effect which, under practical conditions of observation, has always to be taken into account, and which diminishes considerably this theoretically greater efficiency of large apertures; *i.e.*, the greatly increased effect of what may be termed atmospheric aberration attendant upon increase in aperture. The effect of aberration on the definition and the intensity of the image of a line has been investigated by RAYLEIGH (*Phil. Mag.*, Oct., 1879), who finds that in the case of an unsymmetrical aberration varying as cx^3 (a cylindrical wave inclined to the axis of the instrument) the effect of a given disturbance varies as the *cube* of the linear aperture, *i.e.*, if the disturbance is such as to introduce an extreme aberration of one-fourth period (difference of phase between the extreme and central rays) with a given aperture $b_{\prime}$, then an increase of 25 per cent. in the aperture introduces an aberration of, one-fourth period $\times\ (1.25)^3 \doteqdot$ nearly one-half period; and an increase of 50 per cent., an aberration of nearly seven-eighths of a period. Aberration impairs the definition by increasing unduly the importance of the first lateral band of the diffraction pattern, and likewise reduces the *contrast* by diminishing the intensity at the center of the image of the line; the effect upon the intensity of the central portion of the image of a surface being negligible. In the above case (rectangular aperture, unsymmetrical aberration) the intensities at the center of the image of a line would vary in ratio,

For zero-aberration,	1.00
For aberration amounting to ¼ period,	.95
“ “ “ “ ½ period,	.78

Hence a given disturbance sufficient to introduce an aberration of the above character amounting to one-fourth period would reduce the intensity at the center of the line, and therefore the contrast, about 5 per cent. This same disturbance would, with an aperture only one-fourth larger, introduce an aberration of nearly one-half a period, and reduce the contrast 22 per cent. For a circular aperture the effect of an increasing aberration upon the diminution of intensity is somewhat greater.

With a symmetrical aberration (spherical disturbance) and circular aperture the effect of a given disturbance will vary as the fourth power of the aperture, and the intensity will fall off even more rapidly with an increase in aberration.

Thus we have for this case,

For zero-aberration,	1.00
For aberration amounting to ¼ period,	.80
“ “ “ “ ½ period,	.39

These numbers would be increased somewhat if the focus were adjusted for each change in aberration. But in general, in the case of atmospheric disturbances, this would not be possible for the reason that the effect is continually and rapidly varying.

In general, then, we must introduce in the expression for i a factor h, whose value will vary from 0.98 (for sensibly perfect definition) to less than 0.4 for an aberration amounting to only one-half a period. We obtain then for K

$$K = \frac{i_{\prime\prime} + hi}{i_{\prime\prime}} = 1 + h\,\frac{k}{k_{\prime\prime}} \cdot \frac{8}{3\pi} \cdot \frac{b}{\lambda} \tag{6}$$

If we assume the smallest difference in intensity which can be perceived by the eye to be two per cent., we have at the limit of visibility

$$K - 1 = \frac{102}{100} - 1 = 0.02$$

whence

$$\frac{k}{k_{\prime\prime}} = 0.02 \cdot 1.16\,\frac{\lambda}{b} \cdot \frac{1}{h} \doteqdot 0.02\,\frac{\alpha}{h} = \frac{1}{\Delta} \tag{7}$$

where α is the resolving power of a circular aperture.

The quantity Δ may be termed the discerning power of an optical instrument. It is the ratio between the intensity (per unit-area) of a surface, and the intensity (per unit-length) of the faintest line that can be seen projected against that surface.

If h were unity, *i.e.*, if there were no atmospheric aberration, the discerning power of an instrument would, as already stated, vary directly as its linear aperture. But for a given atmospheric disturbance of magnitude e, h is a function of the third or fourth power of b (according to the nature of the disturbance) and will therefore decrease much more rapidly than b increases. For each value of e there will be a value of b for which we will have

$$\Delta_e = \text{const.}\ b \,.\, h = \text{maximum} \tag{8}$$

and for any value of b larger than this the value of Δ will decrease very rapidly. That is, *it is not only useless, but a very great disadvantage*, to use, for observing linear markings on a planetary surface, a telescope having an aperture larger than a certain size, the increase in size actually obliterating lines that might at the same time be seen in a smaller instrument.

Just what this maximum size is depends on atmospheric conditions, and must be determined largely by experience. In some localities ten inches might be as large as could ever be used to advantage; in others the maximum power of apertures two or three times this size might be attained. It would be of the greatest interest to determine the maximum aperture that could ever be used with efficiency for this purpose, but with the meagre data at present available it is only possible to arrive at a very rough idea in regard to this. Considerations of the wave-theory (Rayleigh, "Wave Theory," *Enc. Brit.*, Vol. 24) lead to the conclusion that it is not until the aberration, either instrumental or atmospheric, amounts to at least one-quarter period, that the effect on the definition, so far as this is determined by the sharpness of outline, would begin to be noticed. Up to this point the seeing, from an astronomical standpoint, would still be pronounced "perfect," *i.e.*, 5 on a scale of 5. With an aberration amounting to one-third period the seeing would probably still be pronounced "good," perhaps 4 on the same scale as before. Now with the most powerful instruments yet used, the Lick and the Yerkes telescopes, the seeing is very rarely perfect, and it would probably be unsafe to assume that the aberrational disturbances ever (save at only the briefest intervals of time, so brief and transitory as to be lost for observational purposes) amount to less than one-fourth period. For these instruments, therefore, the maximum value of h would be 0.8, and the product bh would (for a 40-inch aperture) be

$$bh = 32$$

The aberrational effect of this same degree of disturbance on an instrument of smaller size would decrease in the inverse ratio of the third to fourth power of the aperture. Hence with an instrument of an aperture about one-eighth smaller (35 inches) the extreme aberration would be between two-thirds and four-sevenths as great as before, *i.e.*, would amount to a little more than one-seventh period. For this amount of aberration the value of h would be raised to about 0.93. The product bh, is therefore slightly greater than before, thus

$$bh = 35 \times 0.93 = 32.5$$

or an instrument of 35 inches aperture would, under the conditions assumed above, have a slightly higher discerning power than one of 40 inches aperture. Below 35 inches, however, the efficiency would diminish almost directly as the aperture; h having already attained (at 35 inches) very nearly 95 per cent. of its maximum value of about 0.97 to 0.98.

It must be insisted upon that this conclusion is based entirely upon the assumption that the atmospheric aberration with a 40-inch aperture is never less than one-fourth period. This assumption was made in order to be duly conservative in regard to the possible advantages of very large instruments. If there were times at which the effect of atmospheric disturbances were less than this it would follow that the limit of efficient size would be somewhat greater than is indicated above.*

Of course the available time of "good" seeing (*i.e.*, good as judged by that particular instrument) would be greater the smaller the aperture. If we assume that the time t during which the atmospheric disturbances will not exceed a certain amount is proportional to the magnitude e of this disturbance, and that as assumed above the effect of e is proportional to between the third and fourth power of the aperture; it would follow that the time t, during which a certain grade of seeing was attained would vary as $\frac{1}{b^3}$ to $\frac{1}{b^4}$, *i.e.*, in the long run the total time of good seeing with a 20-inch glass would be something like ten to twelve times as great as the total time during which the seeing was of the same order with a 40-inch glass.

As a matter of fact the ratio of t to e is likely to be even more unfavorable than has been assumed, particularly when very large apertures are in question. This would mean that, for work requiring a certain grade of definition, considerably more than ten times the *quantity* could be accomplished with a telescope of 20-inches than could be accomplished with one of twice its size. But when it is a question of verifying or disproving a given observation in the nature of a linear marking on a planetary surface it is not *quantity*, but *quality* of work — not the total *time* available for observation, but the *power* of observation at chosen times — that is or should be decisive. I will venture to say, too, that there is no telescope so unfavorably situated that there are not times at which the atmospheric conditions are good enough to permit of all the advantages commensurate with its aperture being attained. No one observatory, therefore, can claim a monopoly with reference to efficiency in planetary study, although it may, from its location, be able to advantageously devote *more time* to such work than another.

Another point of interest in this connection is with

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*To show how small an effect will produce this amount of aberration let us consider the amount of temperature disturbance within the tube of the telescope which would be sufficient to introduce a phase-difference of one-fourth period in the rays passing through different parts of the tube. Rayleigh has shown (*Phil. Mag.*, Nov., 1879, p. 410) that such an effect will be produced by "a stratum of air . . . . 12cm. long, heated one degree Centigrade," . . . . (over the rest of the air in the tube), ... "lying along the top of the tube, and occupying only a moderate fraction of the whole volume." If this stratum extended the full length of the tube of the 40-inch (length over 1800cm.) the difference in temperature between it and the rest of the air in the tube would have to be *less than one one-hundred-and-fiftieth of a degree Centigrade*, (or less than $\frac{1}{250}$° F.) to introduce an aberration of one-fourth period. If, as Rayleigh says, "the change of temperature progressed uniformly from one side of the tube to the other, the result would be a lateral displacement of the image without loss of definition, but in general both effects would be observable."

reference to the actual *width* of lines which are just visible. This is a question that has already been investigated by MICHELSON (*Astrophysical Journal*, Vol. II, p. 60, June, 1895) who has worked out the case for a rectangular aperture (which is very nearly the same as a circular one) for an infinitely long line on an infinitely extended background.* The expression for the limiting width of a short line just visible against a source of finite size, with an instrument of *circular* aperture of diameter b, is readily obtained from (3) and (5) thus.

The brightness k of the line is by definition the apparent intensity per unit-length when seen alone. When the line is *on* the surface, the uniform continuity of the illumination of the latter is interrupted, and for points near the line (4) would no longer hold. In this case, in determining contrast, we must define k as the *effective* brightness of the line, thus (see paper already referred to in *Astrophysical Journal*, Aug., 1897)

$$k = (k_{\prime\prime} - k_{\prime})\,\sigma \tag{9}$$

where $k_{\prime}$ is the real brightness of the line *per unit of surface*, and σ the angular width of the line (supposed small in comparison with the revolving power of the aperture through which it is viewed). Further we have, as already shown,

$$\frac{8}{3\pi}\cdot\frac{b}{\lambda} = \frac{1}{\alpha}$$

Substituting in (6) we get

$$K - 1 = h\,\frac{k_{\prime\prime} - k_{\prime}}{k_{\prime\prime}}\cdot\frac{\sigma}{\alpha} \tag{10}$$

which (omitting the factor, h) is the form obtained by MICHELSON.* If we assume as before [see (7)] that the eye can perceive percentage differences of brightness of two per cent., we would have for the width of lines just at the limit of visibility

$$\sigma = 0.02\,.\,\alpha\,\frac{1}{1-\dfrac{k_{\prime}}{k_{\prime\prime}}}\,.\,h \tag{11}$$

The following table gives the value of $\frac{\sigma}{\alpha}$ for different values of $\frac{k_{\prime}}{k_{\prime\prime}}$, from 0 (line absolutely black), to $k_{\prime} = 0.9\,k_{\prime\prime}$ (difference of intensity of 10 per cent. only); for two degrees of contrast, *i.e.*, $K - 1 = 0.02$ (lines barely visible), and $K - 1 = 0.05$ (lines distinct). The value of h is taken as 0.93, corresponding to the assumed best conditions of observation with a telescope of 35 inches aperture.

TABLE I.

$\frac{k_{\prime}}{k_{\prime\prime}}$	$\frac{1}{1-\frac{k_{\prime}}{k_{\prime\prime}}}$	$\frac{\sigma}{\alpha}$		$\frac{k_{\prime}}{k_{\prime\prime}}$	$\frac{1}{1-\frac{k_{\prime}}{k_{\prime\prime}}}$	$\frac{\sigma}{\alpha}$	
		$K-1=0.02$	$K-1=0.05$			$K-1=0.02$	$K-1=0.05$
0.0	1.00	0.022	0.054	0.5	2.00	0.043	0.11
0.1	1.11	0.024	0.059	0.6	2.50	0.054	0.14
0.2	1.25	0.027	0.067	0.7	3.33	0.072	0.18
0.3	1.43	0.031	0.077	0.8	5.00	0.11	0.27
0.4	1.67	0.036	0.090	0.9	10.00	0.22	0.54

Thus it would appear that with a 35-inch telescope, for which $\alpha = 0''.13$, (assuming mean wave-length, λ, to be 5500 tenth-meters) it would be just possible, under what has been assumed to be the best attainable conditions, (an atmospheric aberration amounting to one-fourth period in the case of a 40-inch aperture, or about one-seventh period for a 35-inch), to perceive on the uniformly illuminated portions of the lunar and planetary surfaces a line about $0''.0029$ wide, if such a marking were absolutely black, and to perceive distinctly linear markings $0''.07$ wide, which differ only 10 per cent. from the adjoining surface in intensity. These quantities correspond to actual widths of about 20 and 500 feet respectively in the case of the Moon at nearest approach to the Earth; and to widths of about 3000 feet and 14 miles in the case of *Mars* under similar circumstances.

There is one other effect of a physiological (or psychological) nature which has to be taken into account in considering the relative advantages of large *versus* small telescopes in the observation of objects of finite area. It is well known that comets, nebulas, etc., especially when small and faint, are seen much better and *appear* much brighter in a large telescope than in a small one, in spite of the well known fact that it is impossible to increase the apparent brightness of any extended object by instrumental means, and that on the contrary an increase in aperture really *diminishes* the contrast between such objects and the telescopic field. It is also a well known fact that objects can be seen with a telescope on a dark night long after they have become invisible to the unaided eye (see particularly paper by Professor HOLDEN in the *American Journal of Science*, 1881, which concludes as follows: "So far as I know, there is no satisfactory explanation of the action of the ordinary night-glass nor of the similar effect when large apertures are used.") The explanation of the latter phenomena, which is evidently closely analogous to the first, was first given by Lord RAYLEIGH, (*Camb. Phil. Soc.*, Vol. 4, p. 197, March, 1882), who showed that the question of the visibility of faint objects was largely one of apparent angular magnitude, *i.e.*, that a large object of given apparent brightness would be seen when a small one of the same brightness would be invisible. After detailing certain experiments which confirm this theory, the writer concludes, "There seems to be no doubt that the explanation is to be sought within the domain of physiological optics. It has occurred to me as possible that with the large aperture of the pupil called into play in a dark place, the focussing may be very defective on account of aberration. The illumination on the retina might then be readily less in the image of a small than in the image of a large object of equal 'apparent brightness.'" Although such an effect would play a less important part in the visibility of fine lines than in the case of surfaces, it would undoubtedly have some effect, and in so far as it did it would make a large telescope more efficient for observing these markings than a small one.

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* Curiously enough, owing to the omission of the coefficient of one of the integrals, (that expressing the intensity in the image of the line) the result obtained in this investigation is in reality that for a line of finite width upon a finite surface. The correct expression for circular apertures for the other case (long line on extended surface) has been given by the writer in the paper referred to at the beginning of this article, and its bearing upon the problem of photographing meteor trails, lightning flashes, etc., pointed out in a paper, "On the Form of Instrument best adapted for the Photographic Observation of Meteor Trails," soon to be published; probably in the *Astronomical Journal*.

Conclusion. It would appear from the preceding considerations that from an optical point of view there is an advantage in increasing the apertures of telescopes intended for visual observations of planetary detail (in the nature of linear markings) up to such a point that the atmospheric aberration will amount to about one-seventh or one-eighth period under the best conditions of observation. Beyond this point the efficiency actually falls off, *i.e.*, further increase in aperture tends to blot out faint lines instead of increasing their distinctness. The somewhat meagre evidence at present available would indicate that an aperture of between 30 and 35 inches is somewhere near the limit of efficient size, or at any rate that with this size the limit is being rapidly approached.

There is, unfortunately, another element of uncertainty in planetary observations which is far more difficult to deal with than the question of the aperture of the telescope or the effect of atmospheric disturbance, *i.e.*, the question of personality.

To judge from some of the results that have recently been reported as the fruits of observation with comparatively small telescopes, we would be forced to conclude that some observers are able to distinguish contrasts which differ by as little as one-half of one per cent., or less, instead of the two per cent. usually taken as fixing the limit of visibility under favorable circumstances.* Without commenting upon this fact in any way, it may be said that the advantage of employing some agent of observation less susceptible to personal peculiarities than the human eye, will, or ought to be, universally admitted. Such an agent is the photographic plate. The various advantages of the photographic over the eye-and-hand method of delineating the form and surface markings of the celestial bodies (on the score of *accuracy* alone), have been reviewed by the writer in another paper (*Pop. Astron.* Aug., 1897, p. 200), in which the problem of planetary photography has been briefly referred to. It appears from certain investigations on which I have been engaged with reference to this problem, that the limit of efficient size is more quickly reached in the photographic than in the visual method. The decreased contrast (in case of linear markings) resulting from using a smaller aperture, would be to some extent counterbalanced by the ability of the photographic plate to record under proper conditions smaller percentage differences of brightness then can be observed with the eye (the normal eye, at least) directly. (Sir William HUGGINS's Bakerian lecture on the Solar Corona, *Proc. Roy. Soc.*, Vol. 39, p. 108, 1884.) And the satisfaction of being able to *rely* on the records furnished by photography will go far toward compensating us for the failure of this agency to record some of the fainter details that might be just within the reach of the larger instruments, which it would be possible to employ visually. So far, it is true, photographic methods have not succeeded in giving us anything like the detail that is visible to any one on the planetary surfaces in a telescope of comparatively small size. This, however, is not in itself decisive against photographic methods; it simply indicates that the particular ways in which these methods have been applied heretofore have not perhaps been the ones calculated to secure the best results. "There seems to be no good reason why we should not, under proper conditions, photograph all or even more (on account of greater resolving power and greater light-action) than we can ever be sure we really see (up to a certain size of aperture not greater than 12 to 15 inches), on a planetary surface." In a future paper I propose to indicate a method of avoiding what has appeared to me to be the main cause of difficulty in planetary photography, *i.e.*, unsteadiness of the image during exposure, and to describe what has so far seemed (a continuation of the experiments in which I have been engaged may induce me to change my ideas in regard to some minor points of the design) to be the most efficient instrumental equipment for carrying it out.

Yerkes Observatory, 1897 *July* 24.

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*In the case of interference-fringes the limit is higher; 4 per cent. of contrast between adjacent light and dark portions of the pattern being found necessary in order to distinguish the fringes (see experiments of RAYLEIGH, *Phil. Mag.*, June, 1889, p. 486, and of MICHELSON, *Phil. Mag.*, Sept., 1892, p. 280).

ON THE COMPANIONS TO *VEGA*,

By E. E. BARNARD.

In *A.J.* 412, p. 30, Mr. G. Anderson, of the U.S. Naval Observatory, has a note "On the Recently Announced Companion to *α Lyrae*."

Mr. Anderson seems to think the present star is identical with one "discovered by him in 1881" with the 26-inch at Washington, and which was measured by Professor Hall in $s = 51''.48$, $p = 292°.9$.

Mr. Anderson's star was discovered by Winnecke in 1864, and is the well-known Winnecke-companion to *Vega*. Though fainter than the old Struve-companion, it does not require a very powerful telescope to see it, for it was discovered with the Pulkowa 15-inch. The present companion does not have anything to do with Winnecke's star, and is much fainter. Indeed, its position was measured with reference to Winnecke's companion 1897 May 28: $p = 35°.3$, $s = 31''.26$. According to a note made at the time, it was one-half as bright as Winnecke's star. Its position with reference to *Vega* is $p = 312°$, $s = 53''$ (the measures having been made with a temporary micrometer, the value of whose screw is not yet accurately determined).

On the above date Winnecke's companion was measured with reference to *Vega*: $p = 288°.9$, $s = 53''$.

Prof. Schaeberle has kindly supplied me with the following measures of the Winnecke-star with the 36-inch of the Lick Observatory, 1897 July 3: $p = 287°.4$, $s = 53''.2$.

The proper motion of *Vega* ($0''.359$ in $34°.3$, according to Mr. Burnham), has increased the distance of this star a couple of seconds, and diminished the angle 4° or 5° since Prof. Hall's measures in 1881.

Prof. Hall (Wash. Obs., 1888, Page E 149) has attributed the discovery of this star to Mr. Anderson on 1881 July 2. This, however, as I have said, is a mistake, for it was discovered and measured by Winnecke in 1864.

The new star was not known until found with the 40-inch. Of course, from its distance, the companion doubtless has no connection with *Vega*, and is only noted as a light-test. A considerably fainter star, however, could have been seen in the same position with the great telescope.

I take this occasion to note that in *A.J.* 412, p. 28, I have interchanged the declinations of the beginning and end of the meteor-trail.

Yerkes Observatory, Williams Bay, Wis., 1897 *Sept.* 20.

OBSERVATIONS OF THE PARTIAL SOLAR ECLIPSE, 1897 JULY 28,

MADE WITH THE 7½-INCH REFRACTING TELESCOPE OF THE LAWS OBSERVATORY OF THE UNIVERSITY OF MISSOURI, COLUMBIA, MO.,

By MILTON UPDEGRAFF.

	Central Mean Time (90th meridian) h m s	
1st contact	19 25 33.7	about 2^s late; ☉'s limb very unsteady.
2d contact	21 45 18.0	seeing good.

The above times, as computed from the data given in the *American Ephemeris*, are $19^h\ 25^m\ 35^s.4$ and $21^h\ 45^m\ 21^s.6$ respectively.

The observations were made by eye and ear, using a sidereal chronometer which was compared both before and after the observations with the sidereal clock. The observed times were reduced to the Central Mean Times given above.

The contacts of the preceding limb of the sun with the umbra of a sunspot near the sun's western limb were observed as follows:

	Central Mean Time h m s
1st contact	19 34 9.3
2d contact	19 34 36.2

CONFIRMATIONS OF VARIABILITY,*

By ROBERT H. WEST.

C.DM. −36°8854.

The variability of this star, and the two following stars, was announced by Kapteyn, *A.N.* 3389. Six observations here, between 1897 March 30, magnitude 9.15, and June 25, magnitude 9.5, fully confirm, and indicate a maximum of $8^M.6$ for 1897 May 21.

C.DM. −23°12676.

Four observations show a decrease in light from $10^M.0$ 1897 May 4 to $10^M.4$ June 25. On August 25, the magnitude was observed to be 9.35.

C.DM. −30°18609.

This star has been observed here but twice, 1897 June 30, magnitude 9.7, and August 25, magnitude 7.8, but these two observations leave no room for doubt as to its variability.

Syrian Protestant College, Beirût, Syria, 1897 *August* 26.

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* The confirmation here given by Mr. West, of these three variables discovered by Mr. Innes, permits the following notation to be assigned:

			h m s	° ′		h m s	° ′
Cord. DM. −36°8854	= 4935 *RT Centauri*;	(1900)	13 42 30	−36 21.8;	(1855)	13 39 53	−36 8.2
" " −23°12676	= 5752 *RZ Scorpii*	"	15 58 37	−23 49.5	"	15 55 56	−23 41.8
" " −30°18609	= 7685 *S Microscopii*	"	21 20 48	−30 17.0	"	21 18 7	−30 28.5

Ed.

OBSERVATIONS OF SOUTHERN VARIABLE STARS,

By ROBERT H. WEST.

62. *S Sculptoris.*

Fourteen observations, from August 2 to 1897 January 23, give a maximum of $6^{\mathrm{M}}.1$ for 1896 November 13. When first observed its brightness was $9^{\mathrm{M}}.9$. This of itself seemed inconsistent with Hartwig's period of 183 days, but to further test the question an observation was made 1897 June 30, when the star was found to be two steps fainter than the tenth magnitude star C.DM. $-32°65$. Hence Pickering's period of 366 days, as given in the Revised Supplement of the Second Catalogue, is undoubtedly correct.

146. *T Sculptoris.*

I have 16 observations of this star between 1896 August 2 and 1897 Feb. 7. A well-defined minimum, $10^{\mathrm{M}}.8$, was passed 1896 November 10. The last observation, $7^{\mathrm{M}}.95$, was evidently near the time of maximum, but no observations could be made during the preceding fortnight, owing to bad weather, and it is impossible to tell whether the maximum had passed at that time or not. A period of about 200 days is indicated by my observations combined with those of Cordoba.

869. *R Fornacis.*

Ten observations, from 1896 October 28 to 1897 February 27, show a steady increase from $10^{\mathrm{M}}.5$ to $8^{\mathrm{M}}.9$. A provisional period of 410 days is suggested.

1357. *U Eridani.*

When first observed, 1896 Dec. 23, this star was $13^{\mathrm{M}}.5$, and it increased in brightness to $8^{\mathrm{M}}.4$ when last observed, 1897 March 30, with no indication that maximum had been reached.

1386. *T Eridani.*

Thirteen observations, from 1896 December 9 to 1897 March 26, give a fairly satisfactory minimum of $11^{\mathrm{M}}.0$ for 1897 February 27.

1662. *R Caeli.*

This star was observed 9 times, from 1896 December 9 to 1897 March 15, during which time it increased from $<11^{\mathrm{M}}.5$ to $10^{\mathrm{M}}.1$.

1894. *T Columbae.*

Ten observations, from 1897 January 8 to April 8, yield a maximum $7^{\mathrm{M}}.7$ for 1897 February 18, which is 76 days later than the maximum obtained from the elements given in the Third Catalogue.

2059. *S Columbae.*

The brightness of this star diminished, at first rapidly and then more slowly, from $9^{\mathrm{M}}.8$, 1897 January 8, to $<11^{\mathrm{M}}.3$ March 30. There are 9 observations. A comparison with the observations of last year indicates that the period is probably about 200 days.

2080. *R Columbae.*

This star was observed 11 times between 1895 December 26 and 1896 March 18, during which time its light decreased from $9^{\mathrm{M}}.6$ to $<12^{\mathrm{M}}.0$; also 8 times between 1897 January 8 and March 30, when it decreased from $10^{\mathrm{M}}.7$ to $<12^{\mathrm{M}}.0$. Hartwig's elements in the Third Catalogue would call for maxima on 1896 May 2 and 1897 March 26, and therefore need correction. A period of 340 days is suggested.

2776. *W Puppis.*

Ten observations, from 1897 January 14 to April 21, yield a well-defined maximum of $7^{\mathrm{M}}.75$ for 1897 March 1. This, in connection with the maximum of 1896 March 6, would indicate a period of 360 days, or some fraction of that number.

3244. *S Pyxidis.*

From 1897 February 25, the brightness of this star increased from $10^{\mathrm{M}}.4$ to a maximum of $8^{\mathrm{M}}.35$, 1897 May 4, and then decreased from $9^{\mathrm{M}}.1$, June 4. The observations are 11 in number. A period of 213 days is consistent with the observations here and at Cordoba, and hence the following provisional elements are suggested:

$$1887 \text{ January } 27 = J\,2410300 + 213 ?\, E.$$

4225. *X Centauri.*

Observations began 1897 February 27 at or near maximum, $7^{\mathrm{M}}.5$. When last observed, May 22, the brightness had decreased to $10^{\mathrm{M}}.0$.

8622. *W Ceti.*

This star was observed 12 times from 1895 November 8 to 1896 February 10, during which time its brightness increased from $12^{\mathrm{M}}.0$ to $7^{\mathrm{M}}.9$, with no indication that the maximum had been reached. It was also observed 1896 August 2, as $11^{\mathrm{M}}.7$, and 10 times from October 7 to 1897 February 6, the brightness increasing from $10^{\mathrm{M}}.5$ to $7^{\mathrm{M}}.95$, again with no indication that the maximum had been reached. The observations for 1896 December 15, December 23, 1897 January 8, January 18, were $8^{\mathrm{M}}.65$, $8^{\mathrm{M}}.35$, $8^{\mathrm{M}}.45$, $8^{\mathrm{M}}.55$ respectively, which indicates a slight secondary maximum, or a marked "stand-still." This is confirmed by the observations of Mr. H. M. Parkhurst (*A.J.* 400), who has, however, interpreted them as giving the main maximum for 1897 January 3. The light curve this year gives the appearance of a delayed maximum, and there is perhaps no reason to change Paul's elements as given in the Third Catalogue, further than to put the epoch later and give a brighter maximum.

Syrian Protestant College, Beirût, Syria, 1897 *August* 25.

OBSERVATIONS OF *CHALDAEA* (313),

MADE AT THE SAYRE OBSERVATORY, SO. BETHLEHEM,

By JOHN H. OGBURN.

1897 Bethlehem M.T.	$*$	No. Comp.	(313) — $*$ $\Delta\alpha$	(313) — $*$ $\Delta\delta$	Planet's Apparent α	Planet's Apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
h m s			m s	′ ″	h m s	° ′ ″		
March 31 10 7 19	1	8 , 9	−0 8.29	−4 2.0	14 8 38.74	−3 20 30.6	n9.540	0.776
April 1 10 32 39	1	8 , 7	−0 49.87	+7 53.6	14 7 57.16	−3 8 35.0	n9.487	0.777
3 10 10 49	2	5 , 6	+0 30.26	+5 51.0	14 6 32.37	−2 45 16.8	n9.510	0.774
3 11 15 7	3	5 , 7	−0 58.17	+5 12.8	14 6 30.37	−2 44 44.9	n9.352	0.778

Mean Places for 1897.0 of Comparison-Stars.

$*$	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	14 8 44.33	+2.70	−3 16 9.2	−19.4	Brussels 5479
2	14 5 59.38	+2.73	−2 50 48.2	−19.6	Brussels 5734
3	14 7 25.81	+2.73	−2 49 38.1	−19.6	$\frac{1}{3}$ (Cincinnati + Gould 19275 + Brussels 5744)

Adopted proper motion for $*$3, $\mu = -0^s.0128$, $\mu' = -0''.284$, has been applied.

A NEW STAR IN THE NEBULA OF *ORION*,

By F. P. LEAVENWORTH.

A new star has appeared in the nebula of *Orion*, as shown by three photographs taken at this observatory on Sept. 22, 23 and 26. It is found on the southern edge of the nebulous mass *G*, and in line with the south preceding edge of *H*. [See index-map, Publ. McCormick Observatory, Vol. I, part 3, p. 44; or HOLDEN's Monograph of Nebula of *Orion*, page 9.] In brightness it is about equal to star 671, or 11^M. On a plate taken 1897 Jan. 25, the star is not visible, although star 676, of 13^M, is distinctly shown. On Feb. 24 it was of about the same brightness as 676.

University of Minnesota, 1897 *Sept.* 27.

NEW ASTRONOMICAL WORKS.

J. SCHEINER: *Die Photographie der Gestirne* is a work which presents the subject of Celestial Photography as an exact branch of Astronomy. The four chapters of Part I are devoted to the technique and the optical principles; to the instruments employed; to the methods of measurement and reduction of photographic plates (with extensive developments of formulas, extracted chiefly from the *Bulletin* of the Committee on the Astrographic Chart); and to the photographic methods of registration. Part II (pp. 210–256) discusses photographic photometry and the genesis of photographic images. Part III (pp. 257–338) gives the history and achievements of celestial photography, dealing successively with the principal objects. A bibliography is added to the volume, which is accompanied by a separately bound atlas containing eleven admirable heliogravures of the best specimens of celestial photographs obtained at various observatories. E. B. F.

Die Photometrie der Gestirne. Prof. Dr. G. MÜLLER. Leipzig, 1897.

An important gap in astronomical literature has at last been filled by this general handbook of celestial photometry. The whole work, of 556 pages, is divided into three sections; of which the first (pp. 3–144) is devoted to theoretical astrophotometry, the second (pp. 147–304) to photometric apparatus, and the third (pp. 307–510) to the results of photometric observation. An appendix (pp. 511–545) contains tables and a bibliography.

The first, or theoretical portion, is comprised in three chapters, relating, respectively, to the fundamental theorems of the subject, their application to the most important problems of celestial photometry, and the extinction of light in the earth's atmosphere. The results of modern theoretical inquiry, especially SEELIGER'S, are fully and systematically presented.

In the second section the first two chapters are occupied with the description of the various photometers based on the principle of the extinction or of the equalization of the optical images; the third chapter, with the various forms of spectral photometers; and a fourth chapter is devoted to the instrumental methods of investigating thermic and chemical radiations, including the use of photography as a photometric agent.

Finally, in the third section there are given, in five chapters, the photometric results reached by various observers with respect to the sun, the moon, the planets and their satellites, the comets and nebulas, and the fixed stars. The last mentioned chapter is naturally by far the most extensive, relating principally to that most fruitful of all the subjects of application of celestial photometry, the variable stars. C.

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NOTES ON VARIABLE STARS, — No. 20,

By HENRY M. PARKHURST.

Diffraction. Upon reinvestigation of the effect of diffraction upon aperture, by means of observations through a grating placed over the object-glass, I have found it to be inappreciable. (See *Annals H.C.O.*, XVIII, 31.) Consequently, on July 7, 1897, I substituted new logarithmic caps, making no allowance for diffraction. In most cases the difference of scale in the observation of variable stars will be much less than the error of observation.

Factors. When a long interruption occurs, with a small tabular factor (see *A.J.* no. 400), it may be necessary to correct the factor to correspond with the arc interpolated. The most convenient test has been to compare the magnitudes of the last smoothing with the magnitudes corresponding to similar dates before smoothing; for if the correction has been excessive it will make all the numbers too small, and the factor should be increased. In extreme cases, as in the reduction of 7792, one-half the usual arc may be employed, interpolating the mean between each or any two observations, preparatory to smoothing the curve. This reduces the corrections for curvature to one-fourth.

R Comae. In copying the elements for *A.J.* 384, the epoch was made 7 days too late; it should have been 2389885.9. The period has shortened $0^d.6$ each year since 1894.

Y Bootis. The comparisons are with the elements in *A.J.* 384. The suggestion in *A.J.* 329, that some of the transits are partial or entirely missed, is supported by the observations of June 19, contrasted with the repeated failures during the two preceding years to recognize any decided minimum. The observations of Aug. 17 and 30, as indicated by the semicolons, were made with a sky too cloudy for reliance, yet tend to confirm this suggestion.

Results of Observations.

No.	Star	Phase	Observed Date		E	Corr.	W	Mag.	Factors			Remarks
			Julian	Calendar								
				1897							d	
4315	*R Comae*	Max.	4141.2	Aug. 4	67	−0.3	9	8.57	0.15	0.13	4	See note above
4377	*T Virginis*	Max.	4132	July 26	39	–	E	–	–	–	–	Max. lost in twilight
4492	*Y Virginis*	Max.	4128	July 22	24	− 3	1	–	–	–	–	Estimated from light-curve
4521	*R Virginis*	Max.	4068	May 23	221	+ 1	9P	6.8	1.0	0.8	15	
4573	*RU Virginis**	Min.	3978	June 2	1	–	E	11.8]	–	–	–	See note below
"	"	Max.	4206	Oct. 8	1	–	E	–	–	–	–	" " "
4596	*U Virginis*	Min.	4047	May 2	55	−28	5	12.4	–	–	–	
4731	*S Canes Venat.*	–	–	–	–	–	P	–	–	–	–	Comp.stars fluctuate
4826	*R Hydrae*	Max.	4036.5	Apr. 21	5	+ 2	9	4.32	0.17	0.26	4	
"	"	Max. A	4041	Apr. 26	5	+ 7	4P	4.1	–	–	–	
"	"	Max. B	4059	May 14	5	+25	4P	4.1	–	–	–	
4847	*S Virginis*	Max.	4083	June 7	44	0	9	7.73	0.49	0.61	25	See note below
4896	*T Centauri*	Max.	4075	May 29	8	− 8	6P	–	–	–	–	Gould's magnitudes
4948	*R Canes Venat.*	Max.	4063	May 18	10	−35	9	7.35	1.03	0.76	31	Perhaps lost in 384
5144	*Y Bootis*	Min.	4068.567	May 23	430	−0.034	2	–	–	–	–	See note above
"	"	Min.	4094.652	June 18	440	+0.005	6	–	–	–	–	
"	"	Min.	4154.556	Aug. 17	463	+0.003	2	–	–	–	–	
"	"	Min.	4167.560	Aug. 30	468	−0.016	2	–	–	–	–	
5174	*RS Virginis*	Max.	4023	Apr. 8	7	− 7	5	7.44	–	–	–	Double max. uncertain
5194	*V Bootis*	Max.	4051	May 6	18	+24	9	7.66	0.83	0.71	22	Much fluctuation

* The variability of this star, discovered by Roy, was sufficiently demonstrated by his observations, given in *A.J.* XVII, p. 110. But the definitive notation was withheld until confirmation, which is now furnished by Parkhurst. We have accordingly,

4573 *RU Virginis* ; (1900) $12^h\ 42^m\ 13^s$, $+4°\ 41'.5$; (1855) $12^h\ 39^m\ 56^s$, $+4°\ 56'.3$. Ed.

No.	Star	Phase	Observed Date Julian	Observed Date Calendar	E	Corr.	W	Mag.	Factors			Remarks
				1897							d	
5194	*V Bootis*	Min.	4173	Sept. 5	19	−13	9	10.28	1.38	1.16	39	
5237	*R Bootis*	Max.	4133.1	July 27	64	− 3	9	7.85	0.85	0.69	24	
5249	*V Librae*	Min.	4079	June 3	25	–	E	–	–	–	–	Consistent with period in 388
5338	*U Bootis*	Min.	4073	May 28	36	+21	9	11.98	2.00	1.10	44	
"	"	Max.	4120	July 11	36	−27	9	10.68	0.87	1.04	46	
5405	*RT Librae*	Max.	4076	May 31	–	–	2	–	–	–	–	Probably earlier. Period 300?
5494	*S Librae*	Max.	4153	Aug. 16	44	–	E	–	–	–	–	
5501	*S Serpentis*	Max.	4115.0	July 9	69	+29	9	8.77	0.50	0.30	7	
"	"	Max.	4115.5	July 9	69	+29	9P	8.67	0.99	0.95	36	Entirely independent
5511	*RS Librae*	Max.	4058	May 13	13	− 5	4	8.2	–	–	–	Subtangent method
5583	*X Librae*	Max.	4062	May 17	42	+ 8	4	11.5	0.7	0.7	–	

4573. From Roy's observations, *A.J.* 398, I deduce by the subtangent process for a first approximation, 3751+455 E, with which my observations are consistent.

4847. Perry later; perhaps a second max. about July 2.

Individual Observations.

Including Observations by Arthur C. Perry.

4315 *R Comae.*

(Continued from 384.)

Julian	Calendar		Mag.
	1897		
4122.6	July	16	9.4
4125.6		19	9.42_3
4128.6		22	9.00_2
4136.5		30	9.08
4137.6		31	8.88
4138.5	Aug.	1	8.84_2
4139.5		2	8.75_3
4140.5		3	8.57_3
4141.5		4	8.28:
4142.5		5	8.84_3
4143.5		6	8.84_5
4144.5		7	8.73_5
4145.5		8	8.98_2
4148.5		11	8.77;
4149.5		12	9.11_2
4151.5		14	9.12_2

4377 *T Virginis.*

(Continued from 356.)

	1897		
4071.6	May	26	12.0]
4094.6	June	18	11.7]
4096.6		20	12.0]P
4102.6		26	11.7
4102.6		26	12.0P

4492 *Y Virginis.*

(Continued from 384.)

	1897		
4067.6	May	22	12.5]
4094.6	June	18	12.1
4097.6		21	11.3]P
4099.6		23	12.1
4102.6		26	11.6P
4106.6		30	10.48_2

4521 *R Virginis.*

	1897		
4037.6	Apr.	22	9.3P
4044.7		29	8.6P
4045.6		30	8.4P

4521 *R Virginis.*—Cont.

Julian	Calendar		Mag.
	1897		
4051.6	May	6	7.8P
4053.6		8	6.9P
4063.6		18	6.8P
4064.6		19	6.9P
4067.6		22	6.8P
4070.6		25	6.8P
4074.6		29	6.9P
4076.6		31	6.9P
4091.6	June	15	7.6P
4097.6		21	8.2P

4573 *RU Virginis.*

	1897		
4005.6	Mar.	21	11.4]
4010.5		26	11.8
4016.6	Apr.	1	11.4
4018.5		3	11.23_2
4034.6		19	11.15_2
4045.6		30	11.1
4051.6	May	6	10.9
4064.6		19	10.60_2
4076.7		31	10.78_2
4096.6	June	20	10.5
4121.6	July	15	10.4
4136.6		30	10.2

4596 *U Virginis.*

(Continued from 384.)

	1897		
4005.6	Mar.	21	10.8
4010.5		26	11.1
4016.6	Apr.	1	11.7
4018.5		3	11.43_2
4034.6		19	11.72_2
4045.6		30	12.4
4051.6	May	6	12.0]
4064.6		19	11.85_2
4076.7		31	11.13_2

4731 *S Canes Venatici.*

Julian	Calendar		Mag.
	1897		
4037.6	Apr.	22	9.5P
4045.6		30	9.4P
4051.6	May	6	9.4P
4063.6		18	9.4P
4076.6		31	9.5P
4094.6	June	18	9.4P
4102.6		26	9.3P

4826 *R Hydrae.*

(Continued from 326.)

	1897		
4017.6	Apr.	2	5.93_2
4018.6		3	5.49_3
4010.7	Mar.	26	6.7P
4014.7		30	6.6P
4027.6	Apr.	12	5.59_2
4027.6		12	5.2P
4032.6		17	4.49_2
4032.6		17	5.0P
4034.6		19	4.58_2
4034.6		19	4.7P
4035.6		20	4.13_2
4036.6		21	4.53_2
4037.6		22	4.09_2
4037.6		22	4.1P
4038.6		23	4.47_3
4039.6		24	4.71_2
4040.6		25	5.71_4
4044.6		29	4.75_4
4044.6		29	4.3P
4045.6		30	4.4P
4051.6	May	6	4.5P
4053.6		8	4.1P
4063.6		18	4.2P
4064.6		19	4.3P
4067.6		22	4.3P
4070.6		25	4.3P
4074.6		29	4.3P
4076.6		31	4.3P

4826 *R Hydrae.*—Cont.

Julian	Calendar		Mag.
	1897		
4077.6	June	1	3.48:
4078.5		2	4.44_3
4088.5		12	4.80_2
4091.6		15	5.0P
4096.6		20	5.3P
4102.6		26	5.3P
4121.6	July	15	5.6P

4847 *S Virginis.*

(Cont. from 384. Comp. Stars 384)

	1897		
4027.6	Apr.	12	10.54_2
4036.5		21	10.49_2
4050.6	May	5	10.22_2
4051.6		6	9.3P
4053.6		8	9.3P
4060.6		15	9.25_2
4064.6		19	8.8P
4067.6		22	8.77_2
4070.6		25	8.6P
4076.6		31	8.01_2
4076.6		31	8.3P
4087.6	June	11	7.52_2
4088.6		12	8.09_2
4089.6		13	7.66_2
4091.6		15	7.79_2
4094.6		18	7.3P
4102.6		26	7.3P
4128.6	July	22	7.7P
4140.6	Aug.	3	8.0P

4896 *T Centauri.*

	1897		
4064.6	May	19	6.70P
4067.6		22	6.47P
4074.6		29	6.35P
4094.6	June	18	6.70P
4098.6		22	6.82P

4948 *R Canes Venatici.*

(Continued from 384.)

Julian	Calendar		Mag.
	1897		
4027.5	Apr.	12	8.58_2
4031.5		16	9.28_2
4032.5		17	8.46_2
4033.5		18	8.47_2
4034.5		19	8.39_2
4034.6		19	8.9P
4037.6		22	8.2P
4038.6		23	7.94_2
4044.5		29	7.68_2
4045.6		30	7.2P
4050.5	May	5	7.65_2
4051.6		6	7.5P
4060.6		15	7.12_2
4063.6		18	7.5P
4066.6		21	7.47_2
4070.6		25	7.4P
4071.6		26	7.82_2
4076.6		31	7.6P
4087.6	June	11	8.18_2
4088.6		12	8.02_2
4094.6		18	8.3P
4097.6		21	8.31_2
4097.6		21	8.6P
4102.6		26	8.8P
4106.6		30	8.59_2
4115.6	July	9	8.86_2
4116.6		10	8.66_2
4136.6		30	9.6P
4151.6	Aug.	14	10.20_2

5144 *Y Bootis.*

(Continued from 384.)

	1897		
4068.555	May	23	7.63_4
.567			7.91_3;
.585			7.60_3;
4094.569	June	18	7.48_2
.609			8.40_2
.647			8.50_2
.699			8.38_2

5144 *Y Bootis*—Cont.

Julian	Calendar		Mag.
	1897		
4154.531	Aug.	17	7.89_3
.555			8.51;
.576			7.62;
.583			7.88_2
4167.523	Aug.	30	7.88_3;
.575			8.56_3;
.604			7.65;

5174 *RS Virginis.*

(Continued from 384)

Julian	Calendar		Mag.
	1897		
4014.6	Mar.	30	8.0
4016.6	Apr.	1	7.74_2
4017.6		2	7.52_2
4026.6		11	7.41
4027.6		12	7.99_2
4032.6		17	7.79_2
4035.6		20	8.26_2
4038.5		23	8.33_2

5194 *V Bootis.*

(Cont. from 388. Comp. Stars 333)

Julian	Calendar		Mag.
	1897		
4010.6	Mar.	26	8.1P
4014.6		30	7.5
4014.6		30	8.0P
4016.6	Apr.	1	7.90_2
4016.6		1	8.0P
4017.6		2	8.03_2
4018.6		3	7.88_2
4026.6		11	8.34_2
4027.6		12	7.78_2
4031.5		16	7.79_2
4032.6		17	8.0P
4034.6		19	8.0P
4035.5		20	7.92_2
4044.5		29	7.83
4044.7		29	7.9P
4045.6		30	7.9P

5194 *V Bootis.*—Cont.

Julian	Calendar		Mag.
	1897		
4051.6	May	6	8.0P
4052.6		7	7.59_2
4053.6		8	7.57_2
4053.6		8	8.1P
4060.6		15	7.91_2
4063.6		18	7.91_2
4064.6		19	8.1P
4070.6		25	8.2P
4074.6		29	8.47_2
4076.6		31	8.1P
4094.6	June	18	8.4P
4097.6		21	8.8P
4102.6		26	9.02_2
4139.6	Aug.	2	10.00_2
4140.6		3	9.97_2
4151.5		14	10.08_2
4161.5		24	10.03_2
4171.5	Sept.	3	10.56_2
4182.5		14	10.31_2
4192.5		24	10.03_2
4200.5	Oct.	2	9.82_2
4201.5		3	9.48_2

5237 *R Bootis.*

(Cont. from 388. Comp. Stars 333)

Julian	Calendar		Mag.
	1897		
4027.6	Apr.	12	11]
4052.6	May	7	12.5
4064.6		19	11.2P
4070.6		25	11.1P
4076.6		31	10.0P
4094.7	June	18	8.7P
4097.7		21	8.5P
4099.6		23	8.86_2
4102.6		26	8.4P
4106.6		30	8.59_2
4113.6	July	7	8.27_2
4115.6		9	8.1P

5237 *R Bootis.*—Cont.

Julian	Calendar		Mag.
	1897		
4121.5	July	15	7.85_2
4121.6		15	8.3P
4122.6		16	8.23_2
4128.6		22	7.93_2
4136.6		30	8.2P
4138.6	Aug.	1	7.93_2
4142.5		5	8.03_2
4142.6		5	8.2P
4148.5		11	8.42_2
4151.6		14	8.41_2
4157.6		20	8.5P
4163.6		26	8.5P
4168.6		31	8.7P

5249 *V Librae.*

(Cont. from 388. Comp. Stars 388)

Julian	Calendar		Mag.
	1897		
4012.7	Mch.	28 to	
4094.6	June	18	13.0]
	5 dates		

5338 *U Bootis.*

(Continued from 333.)

Julian	Calendar		Mag.
	1897		
4034.6	Apr.	19	11.68_2
4037.6		22	11.24_2
4044.6		29	11.96_2
4051.6	May	6	11.7
4052.6		7	11.74_2
4067.6		22	12.03_2
4076.6		31	11.90_2
4094.6	June	18	11.60_2
4097.6		21	11.53_2
4099.6		23	11.30_2
4125.6	July	19	10.45_2
4128.6		22	11.2P
4136.6		30	10.8P
4138.6	Aug.	1	11.33_2
4140.6		3	11.3P

5338 *U Bootis.*—Cont.

Julian	Calendar		Mag.
	1897		
4142.6	Aug.	5	11.07_2
4142.6		5	11.2P
4149.6		12	11.43_2
4157.6		20	11.9P
4161.5		24	12.0
4162.5		25	11.86_2
4163.6		26	11.7]P

5405 *RT Librae.*

(Continued from 388.)

Julian	Calendar		Mag.
	1897		
4063.6	May	18	8.5
4071.6		26	8.96_2
4074.6		29	8.84_2
4077.6	June	1	8.83_2
4090.6		14	9.1
4091.6		15	9.86_2
4098.6		22	10.2
4102.6		26	10.3
4113.6	July	7	11.8

5494 *S Librae.*

(Continued from 356.)

Julian	Calendar		Mag.
	1897		
4128.6	July	22	8.8P
4140.6	Aug.	3	8.9P
4157.5		20	8.9P
4165.5		28	8.8P

5501 *S Serpentis.*

(Cont. from 388. Comp. Stars 388)

Julian	Calendar		Mag.
	1897		
4027.6	Apr.	12	11]
4037.6		22	11.2
4050.6	May	5	10.98
4053.6		8	11.3P
4064.6		19	11.2P
4067.6		22	10.9
4070.6		25	10.6P
4076.6		31	11.19_2
4076.6		31	10.7P

5501 *S Serpentis.*—Cont.

Julian	Calendar		Mag.
	1897		
4094.6	June	18	9.2P
4097.6		21	9.35_2
4097.6		21	9.0P
4102.6		26	9.29_2
4102.6		26	8.7P
4103.6		27	9.08_2
4108.6	July	2	8.91_2
4109.6		3	8.73_2
4110.6		4	8.93_2
4113.6		7	8.83_2
4114.6		8	8.64_2
4115.6		9	8.88_3
4115.6		9	8.7P
4116.6		10	8.73_2
4121.6		15	9.12_2
4121.6		15	9.0P
4122.6		16	9.24_2
4136.6		30	9.3P
4142.6	Aug.	5	9.4P
4157.6		20	9.7P

5511 *RS Librae.*

(Cont. from 388. Comp. Stars 388)

Julian	Calendar		Mag.
	1897		
4052.6	May	7	8.18_2
4064.6		19	8.19_2
4071.6		26	8.64_2
4077.6	June	1	8.65_2
4091.6		15	10.07_2
4098.6		22	10.3
4102.6		26	10.31_2
4113.6	July	7	11.1

5583 *X Librae.*

(Continued from 356)

Julian	Calendar		Mag.
	1897		
4052.6	May	7	11.7
4064.7		19	11.5
4074.7		29	11.8
4094.6	June	18	12.8

COMPARISON-STARS.

4315 *R Comae.*

1893–1897

Star	DM.		Mag.	*n*
D	+20°2664		7.32	6*M*
F	+19°2526		7.82	26*M*
H	+20°2683		7.86	11*M*
L	+20°2676		8.72	23
P	+20°2670		8.90	21*M*
R	+19°2524		9.36	8
2*R*	+20°2678		9.62	6
3*R*	+20°2686		9.33	2
T	+20°2679		9.66	6
1*U*	+19°2525		10.11	3
X	+19°2529		10.12	3
e	8*s*6*p*	*F*	11.41	2

4492 *Y Virginis.*

1893–1897.

Star	DM.		Mag.	*n*
I	−3°3313		7.48	1
Q	−3°3315		9.00	4
U	−3°3314		9.86	20
W	−3°3312		10.10	19
Y	−3°3318		10.36	5
1*Y*	−3°3320		10.89	1
Z	−3°3317		10.45	4
1*Z*	−3°3319		10.43	5
a	7*p*	*U*	10.51	20
c	4*s*5*p*	*d*	11.31	3
d	12*s*5*f*	*W*	11.31	3
i	2*n*7*p*	*a*	11.98	2

4948 *R Canes Venatici.*

1893–1897

Star	DM.	Mag.	*n*
C	+41°2434	6.87	8
D	+40°2701	7.77	16*M*
I	+40°2703	8.82	17
P	+40°2700	9.52	11
Q	+39°2675	9.30	6*M*
S	+40°2695	9.41	23*M*
T	+39°2685	9.83	17*M*
U	+40°2691	9.87	10
1*U*	+40°2699	9.78	7
W	+40°2690	10.11	6
1*W*	+40°2702	9.83	7
Y	+40°2692	10.41	5

5338 *U Bootis.*

1893–1897

Star	DM.		Mag.	*n*
G	+18°2951		7.74	1*M*
H	+18°2948		8.49	2*M*
I	+18°2955		8.07	2*M*
N	+18°2949		8.97	2
X	+18°2952		10.64	25
Y	+18°2947		10.64	10
Z	+18°2950		10.90	27
1*Z*	+18°2954		10.83	11
2*Z*	+18°2953		10.75	6
f	5*s*	*V*	11.63	20
k	2*s*5*p*	*V*	12.63	9
l	2*n*	*V*	12.38	12

OBSERVATIONS OF COMETS AND ASTEROIDS,

MADE WITH THE 12-INCH EQUATORIAL OF THE U.S. NAVAL OBSERVATORY,

By Prof. E. FRISBY, U.S.N.

[Communicated by Prof. Wm. Harkness, U.S.N., Astronomical Director.]

1896-7 Washington M.T.	*	No. Comp.	☄ − * $\Delta\alpha$	☄ − * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			Comet 1896 VII.					
1896 h m s			m s	′ ″	h m s	° ′ ″		
Dec. 10 6 54 14.1	1	20 , 4	−0 42.28	+ 2 54.6	1 4 13.90	+ 5 43 24.4	*n*8.993	0.684
10 7 5 58.3	2	15 , 3	−1 9.73	+ 0 50.4	1 4 17.63	+ 5 43 10.6	*n*8.876	0.683
11 7 14 38.9	3	18 , 4	−0 48.77	− 2 37.6	1 11 26.45	+ 5 18 0.1	*n*8.807	0.707
23 7 51 32.6	4	20 , 4	+3 29.53	+ 3 35.6	2 31 11.43	+ 1 16 28.6	*n*8.680	0.730
1897 Jan. 6 7 5 39.1	5	20 , 4	−0 59.86	− 1 35.8	3 43 16.82	− 0 41 42.8	*n*9.247	0.748
8 11 20 50.2	6	20 , 4	−1 39.58	− 4 37.8	3 52 32.26	− 0 46 28.1	9.480	0.748
			Comet 1897 I.					
1896 Dec. 9 7 6 54.6	7	15 , 3	−0 13.27	− .0 20.7	19 50 43.46	+ 2 26 19.2	9.631	0.733
10 6 0 39.0	8	14 , 4	+0 47.57	− 8 14.6	19 50 30.91	+ 2 1 56.9	9.563	0.730
11 6 12 24.2	9	18 , 4	−1 19.09	− 3 3.7	19 50 18.17	+ 1 35 41.1	9.619	0.736
23 6 37 0.7	10	20 , 4	+0 42.06	− 1 52.5	19 48 49.66	− 3 0 49.4	9.648	0.749
24 6 20 12.6	11	20 , 4	+0 51.58	+ 0 47.7	19 48 46.01	− 3 22 8.6	9.641	0.751
30 6 27 27.1	12	5 , 1	−0 12.25	− 6 23.8	19 48 34.94	− 5 34 38.9	9.657	0.750

1897 Washington M.T.	*	No. Comp.	Planet − * $\Delta\alpha$	Planet − * $\Delta\delta$	Planet's Apparent α	Planet's Apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			(16) *Psyche.*					
h m s			m s	′ ″	h m s	° ′ ″		
Feb. 23 12 29 14.8	13	20 , 4	+1 26.00	− 1 55.2	10 23 44.69	+10 22 8.6	9.386	0.614
24 10 54 37.9	13	18 , 4	+0 42.38	+ 3 9.9	10 23 1.08	+10 27 13.6	8.808	0.531
			(87) *Sylvia.*					
Feb. 24 11 35 0.2	14	10 , 2	−0 20.30	+11 23.7	10 43 46.02	+23 34 14.2	9.046	9.681
Mar. 10 10 35 42.2	15	20 , 4	−1 53.54	− 6 22.7	10 33 53.08	+24 23 21.2	7.575	0.333
			(190) *Ismene.*					
Mar. 31 12 12 14.7	16	20 , 4	+2 16.58	− 7 37.7	11 55 15.98	+ 1 18 43.4	8.532	0.730
Apr. 1 11 3 37.8	16	20 , 4	+1 45.38	− 2 55.1	11 54 44.78	+ 1 23 26.0	*n*9.007	0.729
3 10 19 4.6	16	20 , 4	+0 39.40	+ 6 39.1	11 53 38.79	+ 1 33 0.3	*n*9.107	0.728
			(113) *Amalthea.*					
May 26 10 26 38.9	17	5 , 1	−2 22.40	+ 3 41.0	15 45 1.90	−11 28 5.3	*n*9.074	0.647
June 2 10 52 54.0	18	20 , 4	+3 11.80	+ 7 42.8	15 38 45.61	−11.24 44.3	7.639	0.831
			(130) *Electra.*					
June 21 11 40 3.0	19	20 , 4	−0 26.23	− 5 12.6	17 3 12.68	+ 6 58 0.9	8.893	0.668
23 12 22 56.8	19	21 , 5	−1 55.91	−11 57.2	17 2 13.00	+ 6 51 16.3	9.254	0.675
25 11 9 17.0	20	20 , 4	+1 14.47	− 7 17.1	17 0 49.34	+ 6 41 2.4	8.730	0.671
			(194) *Prokne.*					
Aug. 26 13 29 37.8	21	20 , 4	−0 14.14	+10 2.2	22 27 49.76	− 6 40 40.6	9.224	0.763
28 11 0 8.0	22	19 , 4	+0 48.45	−12 12.9	22 26 46.79	− 7 16 39.0	*n*9.043	0.756
Sept. 3 11 13 4.0	23	25 , 5	+2 5.02	− 9 3.8	22 23 31.29	− 9 10 46.8	*n*8.519	0.816
4 10 10 47.3	24	20 , 4	−4 56.82	+ 6 25.5	22 23 0.96	− 9 28 39.0	*n*9.171	0.815
8 7 52 55.7	25	30 , 6	+2 22.03	+ 2 45.2	22 21 7.20	−10 39 58.1	*n*9.546	0.812
10 9 43 16.2	26	19 , 4	−5 4.48	− 4 45.6	22 20 11.78	−11 16 40.7	*n*9.180	0.826
15 8 31 30.6	27	20 , 4	+3 27.38	+ 4 5.8	22 18 17.96	−12 39 51.5	*n*9.388	0.825

Mean Places for 1896.0 and 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 4 52.00	+4.18	+ 5 40 2.3	+27.5	Washington Transit Circle
2	1 5 23.18	+4.18	+ 5 41 52.7	+27.5	Washington Transit Circle
3	1 12 11.01	+4.21	+ 5 20 12.0	+25.7	Albany A.G. Zones 353
4	2 27 37.39	+4.51	+ 1 12 29.8	+23.2	Albany 712
5	3 44 14.99	+1.69	− 0 40 13.7	+ 6.7	$\frac{1}{4}$ (München + Weisse + 2 Copeland–Börgen)
6	3 54 10.12	+1.72	− 0 41 55.8	+ 5.5	$\frac{1}{3}$ (Bonn + Schjellerup + Copeland–Börgen)
7	19 50 54.30	+2.43	+ 2 26 32.5	+ 7.4	Albany A.G. Zones 6911
8	19 49 40.91	+2.43	+ 2 10 4.5	+ 7.0	Albany A.G. Zones 6903
9	19 51 34.81	+2.45	+ 1 38 37.8	+ 7.0	Albany A.G. Zones 6914
10	19 48 5.03	+2.57	− 2 59 1.5	+ 4.6	Weisse–Bessell $19^{h}1162$
11	19 47 51.85	+2.58	− 3 23 0.7	+ 4.4	Radcliffe (1890) 5318
12	19 48 44.54	+2.65	− 5 28 18.7	+ 3.6	Schjellerup 7665
13	10 22 16.02	+2.67 +2.68	+10 24 15.9	−12.1 −12.2	Weisse–Bessel $10^{h}345$
14	10 44 3.41	+2.91	+23 23 3.8	−13.3	Weisse–Bessel (2) $10^{h}847$
15	10 35 43.61	+3.01	+24 29 56.9	−13.0	Weisse–Bessel (2) $10^{h}674$–5
16	11 52 56.66	+2.74 +2.74 +2.73	+ 1 26 38.6	−17.5 −17.5 −17.4	Albany A.G. Zones 4385
17	15 47 20.86	+3.44	−11 31 30.5	−15.8	Weisse–Bessel $15^{h}861$
18	15 35 30.34	+3.47	−11 32 11.1	−16.0	Schjellerup 5556
19	17 4 5.41	+3.50 +3.50	+ 7 3 21.4	− 7.9 − 7.9	Bonn VI + 7°3314
20	16 59 31.37	+3.50	+ 6 51 26.9	− 7.4	Weisse–Bessel $16^{h}1081$
*21	22 27 59.59	+4.31	− 6 51 5.7	+22.9	München 31163
22	22 25 54.02	+4.32	− 7 4 48.8	+22.7	Radcliffe (1890) 6041
23	22 21 21.89	+4.38	− 9 2 5.7	+22.7	Radcliffe (1890) 6027
24	22 27 53.38	+4.40	− 9 35 27.8	+23.3	München 31159
25	22 18 40.72	+4.45	−10 43 5.8	+22.5	Radcliffe (1890) 6012
26	22 25 11.80	+4.46	−11 12 18.0	+22.9	Berliner Jahrbuch
27	22 14 46.11	+4.47	−12 44 18.9	+21.6	Radcliffe (1890) 5998

*On account of the large proper motion of this star it was compared on two nights with Radcliffe (1890) 6044 and the mean of the positions taken.

NOTE ON THE PRECESSION OF THE EQUINOXES,

BY JOHN N. STOCKWELL.

The discussion now going on among astronomers in regard to the precession of the equinoxes, has recalled to mind an investigation of the theoretical value of the precession which was made by the writer nearly thirty years ago; and which was published among the *Smithsonian Contributions to Knowledge* for the year 1872, in a Memoir entitled "*Secular Variations of the Elements of the Orbits of the Eight Principal Planets.*" The Memoir closes with a set of tables showing the values of the various elements of the planetary orbits at intervals of one hundred years for a period of 7200 years; but for the earth's orbit they are given with greater elaboration, and extend over a period of 16000 years. They also contain tables of the precession of the equinoxes, in both longitude and right-ascension, and the obliquity of the ecliptic to the equator; and they are very convenient in investigations concerning the celestial bodies during all past historical ages.

The question whether it is advisable to change the value of the constant of precession which has been in continuous use in the *Nautical Almanac,* since 1855, can only be answered in the affirmative, by showing that it is now possible to adopt a constant that is more nearly correct than the one which has been in use during the past forty-five years. Professor NEWCOMB has devoted a good deal of attention to this subject during the past twenty years, and it is fair to presume that he has exhausted the capabilities of the best observations that have been made during the past one hundred and fifty years. His results are embodied in a little work entitled *Astronomical Constants,* published in 1895. On page 196 of that work, I find he gives the following:

Annual precession in longitude,	$50''.2371 + 0''.02218\,t$
Total precession from 1850,	$5023''.71\,t + 1''.109\,t^2$

in which t denotes centuries, counted from the beginning of the year 1850.

If we put $t = +\frac{1}{2}$, we get the annual precession in 1900, equal to 50″.2482. And this, according a recent letter of inquiry from Prof. Harkness, the present Director of the *Nautical Almanac*, is the value which was adopted by Prof. Newcomb in the *Nautical Almanac* for the year 1900.

If, in the expression for the total precession from 1850, we put in succession, $t = -1$ and $t = +1$, we get

	″
Precession between 1750 and 1850,	5022.601
Precession between 1850 and 1950,	5024.819
Total prec. between 1750 and 1950, or 200 yrs.,	10047.420

Now, from the table in the *Smithsonian Contributions to Knowledge*, to which I have already referred, pages 196–7, I extract the following:

	″
Precession between 1750 and 1850,	5022.555
Precession between 1850 and 1950,	5024.818
Total precession in two hundred years,	10047.373

If we compare these last numbers, which are purely theoretical, with the numbers derived by Prof. Newcomb, from a discussion of accurate observations extending over a period of more than one hundred and fifty years, we find a most satisfactory agreement between them. His value of the precession during the hundred years between 1850 and 1950, differs by only 0″.001 from the value which I computed from theory nearly thirty years before; and the total precession during a period of two hundred years, derived from theory, differs by only 0″.047, or less than one-twentieth of a second, from the value deduced from the observations.

Again, if we compute the annual precession for the year 1900, from the data given in my published tables, we find it to be 50″.24818, which is exactly the same as given by Prof. Newcomb in the *Nautical Almanac* for 1900, to a like number of decimals. The perfect harmony between the results of theory and observation, affords satisfactory evidence that both determinations are substantially correct; and that would seem to me to be a sufficient reason for its immediate adoption.

It may, however, be urged that my theoretical computations on that subject were made so long ago that they would hardly correspond with results which would now be derived in the same way, by using the improved values of the elements and masses of the planets. It is true that the mass of *Mars* has since been more accurately determined by means of his satellites, which had not been discovered at that time; but we must remember that the influence of that planet is very small by reason of the smallness of its mass; and the correction of its mass was at the same time quite inconsiderable. But a revision of those old computations by means of modern data is much to be desired; and it is possible that I may at some future time undertake such revision, although I do not think that results materially different would be obtained.

Cleveland, 1897 *September* 30.

NOTE BY THE EDITOR.

Mr. Stockwell's argument in the foregoing article is possibly based on, or may lead to a misapprehension. The total precession in longitude between 1750 and 1950, by Newcomb's determination adopted by the Paris Conference, is 10049″.05. The difference between this and the value derived from Stockwell's theory (10047″.373) is therefore 1″.677, instead of 0″.047.

From correspondence received by the Editor, an analogous confusion seems to have been caused by the circular recently issued from the *Nautical Almanac* office, in the minds of some astronomers, who appear to think that the "new value" of the precession specified in that circular is the one which it is proposed to adopt definitively. It is therefore desirable to explain the matter clearly. Referring to the statements made in the circular as to the anticipation of the action of the Conference by a year, it would appear that the change already made in the Almanac of 1900 is not the one which it is proposed to adopt for the Almanacs of 1901 and thereafter. Thus, if the decision of the Conference is adhered to, we shall have a double discontinuity, or three values of the precession instead of two; namely:

Almanacs of 1855–1899,	$50\overset{''}{.}2638 + 0\overset{''}{.}000227\,(t-1900)$
" " 1900	$50.2482 + 0.000222\,(t-1900)$
" " 1901 and after,	$50.2564 + 0.000222\,(t-1900)$

The second of these is the provisional value in Newcomb's *Elements and Constants;* the last is the value predeterminately accepted by the Conference, and is the one developed in *A.J.* 405 and also, with more detail, in Vol. VIII, Part I, of the *Amer. Ephem. Astron. Papers.*

C.

NOTE ON THE PROPER MOTION OF BRADLEY 2918,

By J. G. PORTER.

This star was observed once by Bradley, in right-ascension only, and his position compared with the Greenwich New Seven-Year Catalogue gives the proper motion $+0^s.0111$, as adopted by Dr. Auwers. But Bradley's right-ascension seems to be more than a second too small, and the star has practically no motion. This appears from the following table, the places being reduced to the A.G. system.

Authority	Epoch	R.A. 1900	Obs.	Epoch	Decl. 1900
		h m s			° ′ ″
Bradley	1754.9	22 6 55.77	1 , 0	–	–11 33 –
Lalande	97.7	57.22	2	1797.7	32.3
Weisse	1822.9	56.99	1	1822.9	32.2
Wrottesley 1	33.0	57.23	10 , 0	–	–
Armagh	42.6	57.25	5 , 0	–	–
Rümker	43.0	57.32	1	43.0	37.0
München	45.4	57.03	2	45.4	33.5
Yarnall	47.7	57.14	5	47.7	32.7
Wrottesley 2	50.9	57.12	5 , 0	–	–
Cape	51.4	57.09	2 , 1	50.5	33.0
Radcliffe 2	58.9	57.05	4	56.5	33.8
Schjellerup	62.8	56.92	1	62.8	32.0
New 7-year	66.3	57.06	2 , 3	66.1	32.9
Poulkova	66.7	57.15	4	66.7	32.0
Bruxelles	67.3	57.00	6 , 3	63.4	32.7
Radcliffe 3	89.0	57.15	3	89.0	32.1
Cincinnati	1894.8	22 6 57.07	3	1894.8	–11 33 32.0

Cincinnati, 1897 *Sept*. 21.

OBSERVATIONS OF *MIMAS* AND *ENCELADUS*,

MADE WITH THE 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY,

BY ORMOND STONE.

As in the case of previous observations the angles given are each the mean of two comparisons; the distances were obtained from measures of double distances. Corrections have been applied for refraction. The times are for the 75th meridian (Eastern Standard).

Mimas-Enceladus.

1895	Eastern Time	p	Eastern Time	s
	h m s	°	h m s	°
May 4	9 56 17	65.54	10 3 24	6.81
	10 16 38	66.58	10 9 30	7.54

Mimas-Tethys.

1895	Eastern Time	p	Eastern Time	s
Apr. 17	11 10 22	40.00	11 19 28	11.71
	11 50 54	48.22	11 22 57	11.97
	. . .	. .	11 27 9	11.82
	. . .	. .	11 32 2	12.29
	. . .	. .	11 39 25	13.03
	. . .	. .	11 42 0	13.24

Enceladus-Tethys.

1895	Eastern Time	p	Eastern Time	s
	h m s	°	h m s	°
Feb. 16	16 25 27	. .	16 38 8	. .
	17 47 48	. .	. . .	. .
Apr. 3	13 9 59	302.34	13 23 2	12.68
	13 16 44	305.17	13 28 42	12.29
10	12 51 35	141.01	13 3 12	23.46
	12 55 30	142.37	13 7 32	23.18
	13 25 45	150.82	13 13 55	22.88
	13 30 8	151.87	13 17 38	22.99
13	12 43 14	86.47	. . .	. .
	12 51 10	86.56	. . .	. .
17	12 20 14	91.72	12 34 28	66.21
19	11 46 12	61.76	11 55 14	13.56
	11 50 26	62.40	11 57 52	13.70
	. . .	. .	12 1 20	13.72
	. . .	. .	12 7 43	14.48
	. . .	. .	12 15 20	14.59
23	10 54 48	149.85	11 13 18	9.69
Apr. 23	11 0 51	153.66	11 19 0	9.63
	11 6 44	156.34	11 47 18	9.00
	11 26 52	161.08	11 51 1	8.77
	11 30 50	162.76	. . .	. .
	11 34 26	163.79	. . .	. .
	11 37 50	165.38	. . .	. .
	11 59 24	173.87	. . .	. .
	12 16 32	180.66	. . .	. .
	12 20 36	183.24	. . .	. .
	12 23 41	183.68	. . .	. .
May 4	9 5 17	322.52	9 10 3	7.31
	9 16 47	324.26	9 13 8	6.64

Enceladus-Dione.

1895	Eastern Time	p	Eastern Time	s
Apr. 10	13 39 55	115.98	. . .	. .
15	11 8 41	98.09	. . .	. .
17	12 26 29	84.68	12 40 29	63.33
	. . .	. .	12 44 35	63.38
	. . .	. .	12 49 10	63.13
20	13 7 26	98.21	13 25 6	37.10
	13 11 42	98.75	13 27 24	36.65

Enceladus-Rhea.

1895	Eastern Time	p	Eastern Time	s
Feb. 16	16 47 19	. .	16 55 46	. .
	17 35 39	. .	. . .	. .
Apr. 20	13 53 15	303.76	14 14 2	29.97
	13 57 56	303.95	14 15 52	29.61
	. . .	. .	14 17 39	29.68
	. . .	. .	14 19 33	29.36
May 22	10 36 18	6.58	10 43 32	29.74
	11 12 54	17.43	10 45 10	29.60
	11 22 46	20.33	10 56 8	29.88
	. . .	. .	10 59 12	30.06
June 2	10 32 22	233.10	. . .	. .
	10 38 36	231.87	. . .	. .
	10 43 10	232.97	. . .	. .

MEASURES OF β 883, β 552 AND *SIRIUS*,

MADE WITH THE 36-INCH TELESCOPE OF THE LICK OBSERVATORY,

BY R. G. AITKEN.

I have recently made two measures of β 883 which may be of present interest in view of the fact that Dr. SEE finds a period of revolution of only five and one-half years for this star (*Monthly Notices*, June, 1897). β 552 is also moving rapidly and seems to have been neglected almost entirely. For comparison, I give the mean of my last year's measures of these stars.

The difference of magnitude in the two components of β 883 is very slight and the quadrant is therefore somewhat uncertain. In 1896, I noted it as "South" on one night, and "uncertain" on the other nights. This year it was marked "North (?)" on the first night and on the second night, with the star on the meridian, "South."

On the last named night the seeing was excellent, and just before sunrise I obtained a measure of the companion of *Sirius*. At the close of the measure the star was only 40^{m} east of the meridian. It may be of interest to add that the companion could be seen clearly after the sun was above the horizon.

β 883 ($7^{\mathrm{M}}+\,..\,7^{\mathrm{M}}+$).

$\alpha = 4^{\mathrm{h}}\,44^{\mathrm{m}}\,33^{\mathrm{s}}$ $\delta = +10^\circ\,52'$

	°	″	
1896.88	196.9	0.28	3 nights
1897.715	30.6	0.23	weight 3
.731	209.9	0.26	weight 4

β 552 ($7^{\mathrm{M}}\,..\,10^{\mathrm{M}}$).

$\alpha = 4^{\mathrm{h}}\,45^{\mathrm{m}}\,3^{\mathrm{s}}$ $\delta = +\,13^\circ\,27'$

	°	″	
1896.88	186.2	0.40	3 nights
1897.715	198.6	0.38	weight 3
.731	198.1	0.48	weight 4

Sirius.

	°	″	
1897.731	175.9	3.92	weight 5

Lick Observatory, University of California, 1897 *October* 2.

CORRECTIONS TO THE ARTICLE, "OBSERVED PLACES OF 310 EPHEMERIS-STARS," IN No. 408,

BY R. H. TUCKER.

The following changes are to be made in my article in *A.J.* 408. None of them affect the places there given, in the second and third columns.

Star	R.A.		For	Put
	h m			
β Androm.	1 3	Obs. – *C.T.*	–0″.1	–1″.1
π_5 Eridani	4 48	. . . .	Eridani	Orionis
22 H. Cam.	6 7	Obs. – *B.J.*	+0″.25	–0″.25
51 H. Cephei	6 51	Obs. – *A.E.*	+1^{s}.060	+1^{s}.065
β Cancri	8 10	Obs. – *C.T.*	+0^{s}.06	–0^{s}.06
τ Hydrae	8 33	. . . .	τ	σ
α Leonis	10 54	. . . .	Leonis	Crateris
σ Leonis	11 15	Obs. – *B.J.*	+0^{s}.023	–0^{s}.023
4 H. Draconis	12 7	. . . .	–78°	+78°
23 H. Cephei	12 18	. . . .	Cephei	Cam.
τ Virginis	13 56	Obs. – *N.A.*	+0^{s}.021	+0^{s}.022
β Librae	15 11	Obs. – *N.A.*	+0″.20	+0″.30

Star	R.A.		For	Put
	h m			
υ Scorpii	17 23	Obs. – *N.A.*	+0^{s}.08	+0^{s}.09
α Ophiuchi	17 30	Obs. – *C.T.*	+0″.8	–0″.8
ϑ Herculis	17 52	Obs. – *B.J.*	–0^{s}.051	+0^{s}.051
ϑ Herculis	17 52	Obs. – *B.J.*	+0″.13	–0″.13
γ_2 Sagit.	17 59	Obs. – *C.T.*	–0^{s}.04	–0^{s}.03
ϵ Lyrae pr.	18 40	Obs. – *B.J.*	–0^{s}.013	+0^{s}.043
μ Aquarii	20 46	Obs. – *C.T.*	+0^{s}.05	+0^{s}.06
61 Cygni pr.	21 2	Obs. – *B.J.*	+0^{s}.185	+0^{s}.181
20 Pegasi	21 55	Obs. – *B.J.*	+0^{s}.058	–0^{s}.058
ϑ Aquarii	22 11	Obs. – *B.J.*	+0^{s}.007	–0^{s}.007
γ Aquarii	22 47	. . . .	γ	λ

The comparison Obs. — *A.E.* for σ_1 *Cor. Bor.*, $16^{\mathrm{h}}\,10^{\mathrm{m}}$, has not been included in the means.
The column *N.A.* includes the stars given in *N.A.* 1897, not found in earlier issues.

Lick Observatory, University of California.

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ON THE CAUSES OF THE SUN'S EQUATORIAL ACCELERATION AND THE SUNSPOT PERIOD.

By E. J. WILCZYNSKI.

Among the maze of facts brought out by the observations of solar physicists, two are of the utmost importance, because they are not isolated facts, but general laws to which all solar phenomena are subject. These laws, the law of rotation and the law of the periodic changes in the solar activity, express numerical relations between measurable quantities. It is the duty of scientists to follow out the consequences of such laws, and to show what conclusions can be drawn from them by legitimate reasoning, thus building up a mathematical theory upon them.

In my inaugural dissertation "*Hydrodynamische Untersuchungen mit Anwendungen auf die Theorie der Sonnenrotation*," Berlin, 1897, and some subsequent papers, which are soon to appear in full in the *Astrophysical Journal*, I have studied these fundamental laws of solar physics in the manner above indicated. It has not been necessary to make any arbitrary hypotheses, the foundation adopted being a very general one. The results are, I believe, of sufficient interest to warrant their publication here.

The general view which I take of our subject is the following. The sun is a fluid body, the general term fluid comprehending both gaseous and incompressible fluids as special cases. Its present condition and the present motion of its parts are but the consequences of its initial condition, and the original motion of its parts, when it still existed in the nebulous state. There is no more reason for assuming that this nebula, when it began to rotate, must have rotated like a solid body, than there is for believing that all planetary orbits ought to be circles instead of ellipses. That is indeed infinitely improbable, being only one out of an infinite number of equally possible cases.

In the course of time, however, the influence of internal friction will have a tendency to give a uniform rotation to the entire mass. But careful investigation shows this influence to be extremely small, not affecting the arc described by any point of the sun by 2′ in 27,500,000 years, under the present solar conditions.

This result is obtained in the course of investigating the following problem. All particles of a viscous fluid describe circles in parallel planes around an axis which is perpendicular to these planes. The conditions for the motion and figure of such a body are to be investigated. The angular velocity of rotation ω is supposed to be different in different parts of the fluid, and is thus introduced as an undetermined function of the coordinates x, y, z. The axis of z is the axis of rotation. The absolute temperature T is also not assumed to be a constant. If ρ and p denote density and pressure, if V is the potential for the point x, y, z of the fluid, if f denote a constant depending only upon the units employed, and if finally $r = \sqrt{x^2+y^2}$ is the distance from the axis of rotation, the following equations are found

$$\left.\begin{array}{lll}(a)\quad f\frac{\delta V}{\delta r} - \frac{1}{\rho}\frac{\delta p}{\delta r} = -\omega^2 r\,, & (b)\quad f\frac{\delta V}{\delta z} - \frac{1}{\rho}\frac{\delta p}{\delta z} = 0\,, & (c)\quad \frac{\delta\omega}{\delta t} = \frac{k}{\rho}\left(\frac{3}{r}\frac{\delta\omega}{\delta r} + \frac{\delta^2\omega}{\delta r^2} + \frac{\delta^2\omega}{\delta z^2}\right) + \frac{\delta k}{\delta r}\frac{\delta\omega}{\delta r} + \frac{\delta k}{\delta z}\frac{\delta\omega}{\delta z}\end{array}\right\} \quad (1)$$

where k, the coefficient of viscosity, is also supposed to vary from point to point. In the derivation of these equations from the most general equations for a viscous fluid, symmetry of all quantities with respect to the axis of rotation has also been assumed, so that the surfaces $\rho =$ const., etc., are all surfaces of revolution.

If $(1)_a$ is differentiated with respect to z, and $(1)_b$ with respect to r, we find

$$\frac{\delta\omega^2}{\delta z} = -\frac{1}{r}\left[f\frac{\delta^2 V}{\delta r\,\delta z} - \frac{1}{\rho}\frac{\delta^2 p}{\delta r\,\delta z} + \frac{1}{\rho^2}\frac{\delta\rho}{\delta z}\frac{\delta p}{\delta r}\right] \qquad 0 = f\frac{\delta^2 V}{\delta r\,\delta z} - \frac{1}{\rho}\frac{\delta^2 p}{\delta r\,\delta z} + \frac{1}{\rho^2}\frac{\delta\rho}{\delta r}\frac{\delta p}{\delta z}$$

so that $$\frac{\delta\omega^2}{\delta z} = \frac{1}{r\rho^2}\left(\frac{\delta\rho}{\delta r}\frac{\delta p}{\delta z} - \frac{\delta\rho}{\delta z}\frac{\delta p}{\delta r}\right)$$

and therefore

$$(2)\quad \left\}\quad \omega^2 = \frac{1}{r}\int_{z_1}^{z}\frac{1}{\rho^2}\left(\frac{\delta\rho}{\delta r}\frac{\delta p}{\delta z} - \frac{\delta\rho}{\delta z}\frac{\delta p}{\delta r}\right)dz + f(r)\right.$$

It is now assumed that the surfaces of constant density coincide with those of constant pressure, *i.e.*, that there exists an equation between p and ρ whose coefficients are independent of r and z. Then the Jacobian

$$\frac{\delta\rho}{\delta r}\frac{\delta p}{\delta z} - \frac{\delta\rho}{\delta z}\frac{\delta p}{\delta r}$$

vanishes, and $\omega^2 = f(r)$, so that ω is a function of r alone. This gives the following theorem.

In a rotating viscous fluid, the angular velocity of rotation is the same for all points whose distance from the axis of rotation is the same, if the surfaces of constant density and constant pressure coincide. If we conceive the axis of rotation to be surrounded by a family of cylinders, *the surface of each cylinder rotates as if it were rigid.*

Equations (1) can now be simplified. Since ρ is a function of p,

$$P = \int\frac{dp}{\rho} \qquad (3)$$

is a definite quantity, and we find

$$\left.\begin{aligned} fV - P &= -\int_{r_0}^{r}\omega^2\,r\,dr + C \\ \frac{\delta\omega}{\delta t} &= \frac{k}{\rho}\left(\frac{\delta^2\omega}{\delta r^2} + \frac{3}{r}\frac{\delta\omega}{\delta r}\right) + \frac{\delta k}{\delta r}\frac{\delta\omega}{\delta r}\end{aligned}\right\}\quad (4)$$

where C, which is the value of $fV - P$ for $r = r_0$ can only be a function of t. As

$$\omega^2 = -\frac{1}{r}\left(f\frac{\delta V}{\delta r} - \frac{1}{\rho}\frac{\delta p}{\delta r}\right) \qquad (4a)$$

it follows that ω^2 could be computed for the outer surface if $f\frac{\delta V}{\delta r}$ and $\frac{1}{\rho}\frac{\delta p}{\delta r}$ were known quantities. As it is, however, *it is impossible to deduce the law of rotation a priori.* If on the other hand the law of rotation has been found by observation, equations (4) give relations between density and pressure. If the fluid is a gas of the same chemical nature through the entire mass, $p = c\rho T$, $k = \beta\sqrt{T}$ where c and β are constants, and the following relations are found,

$$(5)\quad 4\pi f\rho + cT\Delta\log\rho + \frac{r}{\rho}\left(\frac{\delta\rho}{\delta r}\frac{\delta T}{\delta r} + \frac{\delta\rho}{\delta z}\frac{\delta T}{\delta z}\right) = 2\omega^2 + 2r\omega\frac{\delta\omega}{\delta r} \quad , \quad \frac{\beta\sqrt{T}}{\rho}\left(\frac{\delta^2\omega}{\delta r^2} + \frac{3}{r}\frac{\delta\omega}{\delta r}\right) + \frac{\beta}{2\sqrt{T}}\frac{\delta T}{\delta r}\frac{\delta\omega}{\delta r} = \frac{\delta\omega}{\delta t}$$

The last equation gives a very remarkable result. Suppose the temperature to be the same in the entire body, so that $\frac{\delta T}{\delta r} = 0$. Then ρ can be obtained from this equation in the form of a fraction which is equal to a function of r alone. Only when $\beta = 0$ or $\omega =$ const. is this impossible, the fraction assuming then the indeterminate form $\frac{0}{0}$. The result found is this.

In a viscous gas of constant temperature, a circular motion of rotation is only possible when either the surfaces of constant density are cylinders, or when the entire mass rotates like a solid body.

If k is not too great, however, *approximately* circular rotation may take place.

If n denotes the interior normal of any surface of constant pressure $\frac{\delta p}{\delta n}$ is never negative. The application of this condition together with GREEN's theorem, gives the inequality

$$\frac{2\pi f\int\rho\,d\tau}{\int\left(\omega^2 + r\omega\frac{\delta\omega}{\delta r}\right)d\tau} \geqq 1 \quad .$$

where $d\tau$ is the element of volume $dxdydz$, and the integration is to be over the space enclosed by a surface of constant pressure. If ρ and ω are constant, this reduces to

$$\frac{\omega^2}{2\pi f\rho} \leqq 1$$

a well known theorem of M. POINCARÉ.

These general results having been deduced, application is made to the sun. The theorem expressed by $\omega^2 = f(r)$ is supposed to hold. For the surfaces of constant density and constant temperature must both be very nearly spherical, moreover they must coincide at the limiting surface if such exists, this being also a surface of constant pressure. Therefore for reasons of continuity the supposition holds certainly with great approximation near the outer parts, and very probably everywhere. It is now demonstrated that nearly spherical surfaces, $p =$ const., are possible, and their approximate equation is deduced by developments in spherical harmonics, the method being a simple generalization of that of LEGENDRE and LAPLACE. If the density is supposed to be inversely proportional to the square of the distance from the sun's center, we find for the ellipticity of the limiting surface

$$e = 0.00001$$

a quantity too small to be observed, which is in accordance with the fact that no ellipticity has been noticed by the best observers.

If the different laws of rotation disclosed by observations of the different classes of solar phenomena, the sunspots, the *faculae*, and the absorbing layer, are now compared and united by our theorem that ω is a function of r alone, it is found that these different objects must be situated in different levels, and the differences of level can be computed. It is found that *sunspots must be at a higher level than the reversing layer*, the *faculae* being still higher.

Frost has reached the same conclusion independently, adducing additional evidence for the same from other facts.(1) I had reached this and a number of my other results in a paper published over a year ago.(2) But our method does not only give these qualitive differences, but allows the differences of level to be computed. They are found to be surprisingly great, amounting to over one-tenth of the sun's radius. While no overdue value need be attached to the precise numerical results, it is obvious that our entire view requires greater differences of level than are usually accepted. Such great relative motions, if they took place in only slightly different levels, could not persist long, but would have to be constantly renewed.

There seems to be a contradiction here, between theory and direct observation, which puts all of the solar phenomena in only slightly different levels. But this is easily explained if it is noted that in direct observations the refraction in the solar atmosphere ought to be taken into account. Let r_1 and $r_2 > r_1$ be the radii of two spheres in the sun's atmosphere, and let μ_1 and μ_2 be the corresponding values of the index of refraction. Then the distance $r_2 - r_1$ appears to an observer upon the earth to be shortened to $\mu_2 r_2 - \mu_1 r_1$, which, putting $r_2 = 1.1 r_1$, becomes $r_1 (1.1 \mu_2 - \mu_1)$. At the top of the *faculae* probably $\mu_2 = 1$ very nearly, and if in the absorbing layer the region of heavy metallic vapors μ_1 is nearly 1.1, this distance will appear extremely small. Putting $\mu_1 = 1.1$ does not seem extravagant if we remember that in these regions the heavy metallic vapors, as iron vapor, abound. The discrepancy is easily explained in this manner.(3)

Owing to friction the angular velocity in any point is not a constant, but tends in the limit towards a certain value which is the same for the entire mass. I have already mentioned that this gradual progressive change is very slow, a fact which is disclosed by putting plausible values for k and ρ in the formula for $\frac{\delta\omega}{\delta t}$. But besides this there can be periodic changes, the velocity alternately becoming greater and smaller, and the period depending upon the law of rotation.(1)

There will also be survivals of disturbances in the original nebula, the initial conditions determining the periodic changes as well as the law of rotation.

Now according to ($4a$), to such periodic changes in ω must correspond periodic changes in ρ, p and T, and it is easy to see how changes in temperature, for instance, may affect the solar activity. It is also plausible that such changes must affect the electro-magnetic field surrounding the sun, thus showing how the connection of solar activity and terrestrial magnetism may be explained. Comparatively small changes in ω are only needed to change the temperature considerably, but doubtless there are other causes beside the one here mentioned. Some of these are easily enumerated, but it cannot of course be decided as yet which is the most important. It suffices for the present to have shown, that a mechanical explanation is possible. The precise details of this can only be found by observation, as none of the possible causes has *a priori* any advantage over the others.

Chicago, 1897 *October* 13.

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(1) Frost, *AP.J.*, 1896 Oct. (2) Wilczynski, *AP.J.*, 1896 Aug.

(3) Wilczynski, *AP.J.*, 1897 Nov. On the Depth of the Reversing Layer.

(1) Wilczynski, *AP.J.*, 1897 Nov. On the Causes of the Sun-spot Period.

MEASURES OF DOUBLE STARS,

MADE WITH THE 18-INCH EQUATORIAL OF THE FLOWER OBSERVATORY,

By ERIC DOOLITTLE.

The observations of double stars so far made at this observatory have been principally from lists kindly furnished by Mr. Burnham. It is thought best to delay the publication of these observations until they have been duplicated. At the suggestion of Dr. T. J. J. See there was also undertaken the measurement of those stars of which he has computed the orbits. (*Evolution of the Stellar Systems*, Vol. I.) As the motion of most of these pairs can be predicted with much exactness, it is necessary that the measures be made with more than usual care if they are to be of use in the further improvement of the orbits. On this account, the best nights were devoted to these stars, and a large number of measures were taken when possible.

In the following results the fourth column indicates the number of separate settings of the wire for position-angle, and also the number of measures of double distance. During the observations, the line joining the eyes was kept either parallel or perpendicular to the wire. The illumination was at first by electricity, and afterward by an oil lamp. The power used was 700, except in one instance.

I have added to the measures the resulting positions computed by Dr. See. A comparison shows that in a few cases observations are here printed which had better perhaps have been rejected; as they are of unusually difficult pairs, of which observations are few, I have however retained them.

Σ3062. $6^{M}.9$, $7^{M}.5$.

$\alpha = 0^{h}\ 1^{m}.0$, $\delta = 57°\ 53'$.

	°	″	
1897.079	334.04	1.72	4
.178	337 18	1.76	6
.189 (1)	336.46	1.48	6
.192	336.93	1.66	4
.217	338.50	1.68	6
1897.171	336.62	1.66	
See.	336.14	1.45	

(1) Slight wind.

η *Cassiopeae* = Σ60. $4^{M}.0$, $7^{M}.0$.

$\alpha = 0^{h}\ 42^{m}.9$, $\delta = 57°\ 18'$.

1897.189	208.42	4.76	4
.192	208.18	4.83	4
.241	209.40	4.79	4
.288	209.96	4.64	4
.309	209.80	4.71	4
.320	210.08	4.77	4–2
.367	209.03	4.72	4
1897.272	209.27	4.74	
See,	209.63	4.69	

*O*Σ38. $5^{M}.5$, 7^{M}.

$\alpha = 1^{h}\ 57^{m}.8$, $\delta = +41°\ 51'$.

1897.293 (1)	121.6	0.46	4
.299 (2)	133.2	–	4
.714 (3)	117.8	0.41	4–2
1897.508	119.7	0.45	
See.	116.4	0.34	

The middle observation should probably be rejected.

(1) Quite distinct at intervals; I think a good measure. (2) Elongated; uncertain. (3) Not clearly separated.

9 *Argus* = β 101. $5^{M}.7$, $6^{M}.3$.

$\alpha = 7^{h}\ 47^{m}.1$, $\delta = -13°\ 38'$.

1897.293 (1)	292.93	0.77	4
.302 (2)	289.69	0.65	4
.397 (3)	296.22	0.58	4–2
.460 (4)	288.87	0.64	4
1897.363	291.93	0.66	
See,	288.98	0.60	

(1) Not clearly separated. (2) Distinct.
(3) Not clearly separated.
(4) Not entirely separated.

ζ *Cancri* = Σ1196. $5^{M}.5$, $6^{M}.2$.

$\alpha = 8^{h}\ 6^{m}.2$, $\delta = +17°\ 58'$.

AB.

1897.244	13.07	1.41	4
.288	17.90	1.44	4
.291	13.30	1.41	4
.695	11.22	1.22	4
.698	13.68	1.19	4
.714	14.88	1.16	4
1897.488	14.01	1.30	
See,	14.04	1.13	

AC.

	°	″
1897.244	115.64	5.43
.288	112.60	5.48
.293	115.00	5.40
.309 (1)	115.22	5.35
.320	114.92	5.49
1897.291	114.68	5.43

(1) Images sprayed.

Σ3121. $7^{M}.2$, $7^{M}.5$.

$\alpha = 8^{h}\ 6^{m}.2$, $\delta = +29°\ 0'$.

1897.293 (1)	11.62	1.02	4
.299	13.95	0.79	4
.302 (2)	14.44	0.82	4
.320	13.87	0.84	4
.348 (3)	15.77	0.78	4
.367	14.90	0.84	4
1897.321	14.09	0.80	('97.323)
See,	16.25	0.69	

(1) Power of 900. Distance poor; rejected.
(2) Good. (3) Blurred.

ω *Leonis* = Σ1356. 6^{M} , 7^{M}.

$\alpha = 9^{h}\ 23^{m}.1$, $\delta = 9°\ 30'$.

1897.293	111.80	1.01	4
.299	111.55	0.88	4
.367	108.64	0.84	4
.378	111.22	1.04	4
.386	110.30	0.93	4
.389	110.08	0.91	6-4
1897.352	110.63	0.90	
See,	110.08	0.87	

I cannot account for the large distances on two nights.

ξ *Ursae Majoris* = Σ1523. 4^{M} , 5^{M}.

$\alpha = 11^{h}\ 12^{m}.9$, $\delta = 32°\ 6'$.

1897.291 (1)	163.87	2.30	4
.293	166.00	2.18	4
.299	166.22	2.02	2
.309	164.90	2.16	4
.348	166.16	2.06	4
.367 (2)	165.46	2.29	4
1897.318	165.43	2.16	
See,	166.49	1.95	

The first and last observations should probably be rejected.

(1) Images unsteady; wind.

(2) Much blurred.

*O*Σ234. 7^{M} , $7^{M}.8$.

$\alpha = 11^{h}\ 25^{m}.4$, $\delta = 41°\ 50'$.

1897.414 (1)	141.2	–	4
.463 (2)	136.6	–	3
1897.438	138.9	–	
See,	130.5	0.33	

The second measure is certainly the better.

(1) Distinctly elongated.

(2) Separation was at times suspected; no measures of ρ were however attempted.

*O*Σ235. 6^{M} , $7^{M}.8$.

$\alpha = 11^{h}\ 26^{m}.7$, $\delta = 61°\ 38'$.

	°	″	
1897.293 (1)	102.88	0.96	6–3
.320 (2)	96.90	–	4
.397 (3)	100.21	0.86	4
.414 (4)	92.20	–	4
1897.375	98.05	0.91	
See,	98.51	0.77	

(1) Good. (2) Wedge-shaped.
(3) Distinct. (4) Not distinctly separated.

γ *Virginis.* = Σ1670. 3^{M} , $3^{M}.2$.

$\alpha = 12^{h}\ 36^{m}.6$, $\delta = -0°\ 54'$.

1897.288 (1)	331.06	6.06	4
.293	330.97	5.92	4
.436	331.31	5.77	4
.460	330.83	6.02	4–2
.465	330.53	5.81	4–2
.468	331.20	5.89	4
.499 (2)	330.90	–	4–0
.545	331.22	5.68	4
1897.432	330.96	5.73	
See,	330.66	5.90	

(1) Light clouds. (2) Images unsteady.

*O*Σ269. $7^{M}.3$, $7^{M}.7$.

$\alpha = 13^{h}\ 28^{m}.3$, $\delta = 35°\ 46'$.

1897.397 (1)	229.6	0.48	4
.460 (2)	226.8	0.59	4
.468 (3)	216.9 ±	–	4
1897.428	228.2	0.54	
See,	224.1	0.39	

(1) Somewhat uncertain, but distinct at intervals. (2) Very distinct. (3) Elongated.

25 *Canum Venat.* = Σ1768. 5^{M} , $8^{M}.5$.

$\alpha = 13^{h}\ 33^{m}$, $\delta = 36°\ 48'$.

1897.416 (1)	141.6	–	2
.436 (2)	139.6	–	4
.545 (3)	137.2	1.41	4
1897.449	138.8	1.41	('97.545)
See,	133.3	1.13	

This has been a very difficult star to observe. Out of probably as many as twenty attempts to separate it, it was only once seen distinctly. The close agreement of the angles is accidental.

(1) Uncertain. (2) Very uncertain.

(3) Occasionally distinct, but excessively difficult.

*O*Σ285. $7^{M}.5$, $7^{M}.6$.

$\alpha = 14^{h}\ 41^{m}.7$, $\delta = 42°\ 48'$.

1897.545 (1)	122.8
See,	130.1

(1) Elongated distinctly; almost separable.

ξ Boötis = Σ1888. $4^M.5$, $6^M.5$.

$\alpha = 14^h\,46^m.8$, $\delta = 19°\,31'$.

	°	″	
1897.291 (1)	215.40	3.07	4
.293	217.28	2.87	4
.309	212.72	2.84	4
.351	216.62	2.74	4
.378	217.84	2.68	4
.386 (2)	217.20	3.02	4
.389 (3)	216.66	2.93	4
.436	213.32	2.77	4
.468	216.73	2.82	4
.537	218.77	2.72	4
1897.384	216.25	2.85	
See,	216.80	2.55	

(1) Images blurred. (2) Images unsteady.
(3) Haze.

η Cor. Borealis = Σ1937. $5^M.5$, 6^M.

$\alpha = 15^h\,19^m.1$, $\delta = 30°\,39'$.

1897.319 (1)	319. ±	–	1
.414 (2)	330.22	0.53	4
.416 (3)	336.44	0.60 ±	4–2
.545 (4)	328.16	–	4
1897.458	331.61	0.53	('97.414)
See,	326.8	0.44	

(1) Elongated. (This measure is rejected).
(2) Distinct. (3) Good.
(4) Not quite separable.

μ² Boötis = Σ1938. $6^M.5$, 8^M.

$\alpha = 15^h\,20^m.7$, $\delta = 37°\,43'$.

1897.545	80.62	1.04	4
.687	86.40	.99	4
.695 (1)	77.14	–	4
.698	79.03	1.22	4–2
.733 (2)	77.60	1.01	4–2
1897.672	80.16	1.06	
See	80.73	0.86	('97.666)

(1) Elongated. (2) Difficult.

*O*Σ298. 7^M, $7^M.4$.

$\alpha = 15^h\,32^m.4$, $\delta = 40°\,9'$.

1897.309	177.42	1.31	6–3
.545	178.40	1.14	4
.687	182.11	1.18	4
.695	179.39	1.28	4–2
.733	183.04	1.22	4–2
1897.594	180.07	1.23	
See,	180.64	1.08	

ξ Scorpii = Σ1998. 5^M, $5^M.2$.

$\alpha = 15^h\,58^m.9$, $\delta = -11°\,5'$.

	°	″	
1897.545 (1)	222.6	–	4
See,	216.1	0.84	

(1) Elongated.

σ Cor. Borealis = Σ2032. 6^M, 7^M.

$\alpha = 16^h\,11^m$, $\delta = 34°\,7'$.

1897.414	211.44	4.34	4
.425 (1)	211.05	4.51	4
.436	212.44	4.55	4
.468	209.92	4.38	4–2
.545	210.65	4.33	4
.687	213.75	4.47	4–2
.695 (2)	212.88	4.60	4–2
1897.524	211.76	4.45	
See,	211.22	4.30	

(1) Somewhat blurred. (2) Images diffuse.

ζ Herculis = Σ2084. 3^M, 6^M.

$\alpha = 16^h\,37^m.6$, $\delta = 31°\,47'$.

1897.545 (1)	14.62	1.21	4
.695	10.30	1.01	4
.698	16.55	0.82	4–2
.733 (2)	11.07	–	4–0
1897.678	13.14	1.01	
See,	11.49	.78	

(1) Distance evidently in error.
(2) Elongated; difficult.

Σ2173. 6^M, 6^M.

$\alpha = 17^h\,25^m.3$, $\delta = -0°\,59'$.

1897.545	340.24	1.28	4–6
.687	335.18	1.18	4–8
.733	335.65	1.14	4–6
1897.655	337.02	1.20	
See,	335.2	1.19	

The distances were measured with much care, on account of the remarks of Dr. See (*Evolution of the Stellar Systems*, p. 197). The uncertainty of the mean will hardly exceed 0″.1.

F 70 *Ophiuchi* = Σ2272. $4^M.5$, 6^M.

$\alpha = 18^h\,0^m.4$, $\delta = 2°\,33'$.

	°	″	
1897.414	280.37	2.20	4
.416	280.22	2.09	4–2
.425	278.88	2.16	4
.436	276.98	2.14	4
.460	277.22	1.96	4–2
.468	277.04	1.92	4
.537	276.44	2.06	4–2
.545	278.47	2.02	4–2
.644 (1)	277.29	2.10	4
.657	275.60	2.02	4–2
.663	276.31	1.94	4–2
.668 (2)	276.06	2.08	4
.671	275.44	2.03	4
1897.539	277.41	2.05	

(1) Somewhat blurred. (2) Images unsteady.

A.C.

1897.425	218.04	98.64	4–2
.436	217.57	99.06	2
.668	218.75	98.36	4
1897.510	218.12	98.68	

β Delphini = *β*151. 4^M, 6^M.

$\alpha = 20^h\,32^m.9$, $\delta = 14°\,15'$.

1897.537	355.4	0.86	4
.687 (1)	351.2 ±	–	4
.695	359.8	0.80	4–2
.733	358.0	0.72	4
1897.663	356.1	0.79	
See,	359.1	0.72	('97.655)

The second observation should perhaps be omitted.

(1) Elongated.

85 *Pegasi* = *β*733. 6^M, 10^M.

$\alpha = 23^h\,56^m.9$, $\delta = 26°\,34'$.

1897.722 (1)	226.3	0.83	4–2
.760	230.1	–	1
1897.741	228.2	0.83	
See,	222.9	0.70	

(1) Distinctly visible at intervals, but very difficult. Could make no other measures.

University of Pennsylvania, 1897 *Oct.* 17.

OBSERVATIONS OF VARIABLES OF LONG PERIOD,

By PAUL S. YENDELL.

4511. *T Ursae Majoris.*

From 1897 April 28 to August 5, I observed this star thirteen times. A maximum of $8^M.4$ is indicated on June 6. At the last date the star was estimated as $10^M.8$.

4521. *R Virginis.*

Seven observations, from 1897 April 29 to June 27, indicate a maximum on May 23.

4847. *S Virginis.*

I observed this star from 1897 April 29 to Aug. 5. At the first observation it was estimated as of $9^M.3$, from which it increased steadily to a maximum of $6^M.8$, which was passed June 21; both the increase and decrease being sharply marked. At the last observation it had fallen to $7^M.9$.

5501. *S Serpentis.*

Eighteen observations, from 1897 April 29 to August 17, show a maximum of $8^{M}.1$ on July 7. The star was first seen on May 1, when it was estimated as 12^{M}, from which it rose steadily to the maximum, the decrease to $9^{M}.5$, its light when last seen, being considerably slower than its increase.

5955. *R Draconis.*

I have fifteen observations, from 1897 May 4 to Aug. 5, which show a maximum of $7^{M}.8$ on June 13. It was about $9^{M}.3$ when first observed, and at the last date had decreased to $9^{M}.2$.

6005. *S Draconis.*

Fifteen observations, from 1897 May 23 to Sept. 29, indicate a minimum of about 10^{M} on August 5. The decline from the first observation was about a magnitude, and the increase up to the last date was about $1^{M}.2$.

6160. *RT Herculis.*

A faint maximum of this star is indicated on 1897 June 27, the highest light reached being $9^{M}.7$. The phase is quite distinctly marked, both the increase and decrease being sharp and definite. When last seen, August 17, the star's brightness was estimated as about $10^{M}.6$. The observations are fifteen in number, from 1897 May 13 to Sept. 15, on both of which dates the star was not seen, the limit of vision assigned in both cases being about 11^{M}.

6512. *T Herculis.*

Ten observations, from 1897 June 22 to August 20, show a maximum of $7^{M}.5$ on July 22. The star's light was estimated as $8^{M}.8$ at the first observation, and at the last as $9^{M}.3$.

7261. *R Delphini.*

Nine observations of this star, from 1897 August 2, when it was estimated to be $8^{M}.8$, to September 25, when it had faded to $9^{M}.5$, show a maximum of $8^{M}.2$ on August 10. The rise and decline were both rapid, and the maximum was well-defined.

7560. *R Vulpeculae.*

This star was first observed when very near its maximum, on 1897 July 30, its light on that date being by estimation $8^{M}.0$. Seven observations, the last on August 29, indicate, uncertainly on account of the small increase, a maximum of $7^{M}.8$ on August 6. At the last observation, it had dropped to $8^{M}.8$.

Through an error in plotting, the observations published in this *Journal*, Vol. XVII, p. 192, as of *V Andromedae*, were of a star about four minutes following ANDERSON's star. Two observations of *V*, on 1897 August 20 and 26, are fairly in accord with PARKHURST's, published on p. 30 of the current volume, being estimated respectively as 10^{M} and $10\frac{1}{2}^{M}$.

Dorchester, Mass., 1897 *Oct.* 3.

ORBITAL MOTION OF THE COMPANION TO *PROCYON*,

BY J. M. SCHAEBERLE.

It is now practically certain that the companion to *Procyon*, which I discovered last November, is the disturbing body whose existence BESSEL predicted half a century ago.

On several mornings during the present season I saw the companion, but was unable to obtain satisfactory measures owing to the lack of good seeing at the particular times when the telescope was available. The rough measures indicated that the position-angle had increased some eight or ten degrees.

This morning the seeing was excellent;* the mean of eleven good determinations of the position-angle and twenty-three measures of the distance gives

$$1897\ \text{Oct. } 8,\ 17^{h}, \quad P = 324°.09 \pm 0°.18\ ,\ \Delta = 4''.70 \pm 0''.03$$

the probable errors of a single observation being, respectively, 0°.6 and 0″.15.

At the time of discovery (see *A.J.*, No. 389) the position was

$$1896\ \text{Nov. } 13,\ 17^{h}, \quad P = 318°.8\ ,\ \Delta = 4''.59$$

The present annual increase in the position-angle is therefore about 6°. On the hypothesis that the period is 40 years the mean annual motion would be 9°. As the companion is ahead of its predicted place it follows that the difference between the theoretical (circular orbit) and observed place is diminishing at the rate of about 3° per annum. The true orbit is therefore either quite elliptical or much inclined to the line of sight, or both.

Lick Observatory, University of California, 1897 *Oct.* 9.

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* As an indication of the actual brightness of the companion I can state that my last measure was made ten minutes before sunrise, and on sighting along the outside of the telescope tube *Procyon* could no longer be seen with the naked eye in the bright morning sky.

ON THE OBJECT IN THE NEBULA OF *ORION* ANNOUNCED IN *A.J.* 414,

BY F. P. LEAVENWORTH.

On further investigation it seems certain that the star announced in my communication to the *A.J.* No. 414, does not exist, notwithstanding the great probability as shown by three successive appearances on the photographic plate. I wish to give a detailed account of their appearance on the plates.

On Sept. 22 and 23 two photographs of the nebula in *Orion*, taken by Mr. NEWKIRK at this observatory, showed a starlike nucleus on the southern edge of condensation *G*.[1] In appearance they were almost exactly similar to the star 671, both in intensity, and in nebulous form. A plate on Feb. 24 shows a much fainter condensation in the same place. In order to test the reality of this variation, another photograph was taken on the next following clear night, Sept. 26. On it was found a spot identical in appearance and position with those of previous date. This seemed very strong evidence of a new star, and it was so announced.

However, between Sept. 27 and Oct. 4 Prof. BARNARD examined this part of the nebula on several nights, but found no star there as bright as the 14th magnitude. Also on Oct. 5 and 6 photographs taken here failed to show any starlike condensation.

I have therefore made a second very careful investigation of these plates. The distances of the new spot from five neighboring stars was measured with the Repsold measuring machine. The result showed that the spots on Sept. 23 and 26 differed by about 0.015 mm. or less than 1″. On Sept. 22 there is a difference of about 0.1 mm. or 6″ toward the south. On Feb. 24 the spot was so faint that it was observed with great difficulty. Its place differs from that of the 26th by about 0.07 mm. or 4″. The uncertainty of measurement may account for this discrepancy, but the displacement of Sept. 22 is without doubt real, making it certain that the object is not a star.

A second careful scrutiny of all the plates showed there was a faint nebulous line or series of condensations running from *F* to *G*. Prof. STONE mentions one of these in his notes on the nebula of *Orion*.(1) It is also shown in a photograph printed in PICKERING'S "Investigations in Astronomical Photography."(2) In this latter, the appearance is similar to that ordinarily shown on our plates. Where this nebulosity joins *G*, is the point of variation. The starlike condensation appears in every case in this faint mass.

The condensation seen by Prof. STONE seems also to vary in a similar manner but not to so great an extent.

We are finally led to conclude that there is considerable variation in the brightness of this faint nebulosity between *F* and *G*, or else that our photographs can not be relied upon for faint detail.

University of Minnesota, 1897 *October* 13.

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[1] See *Pub. L. McCormick Observatory*, Vol. I, Part 3, p. 45, or *Wash. Ast. and Met. Obs.*, Vol. XXV, Appendix I, p. 9.

(1) *Pub. L. McCormick Observatory*, Vol. I, Part 7, p. 277.

(2) *Annals of Harvard College Observatory*, Vol. XXII, Part I, Plate II, Fig. 6.

NEW ASTEROIDS.

DG	$12^{M}.0$	1897 Sept. 1	$10^{h}\ 0^{m}.0$ Nice M.T.	$\alpha = 22^{h}\ 27^{m}\ 16^{s}$	$\delta = +12^{\circ}\ 6'$	Daily motion, -48^{s} and $4'$ southward.
DH	12.0	1	10 0.0	22 30 48	+ 6 8	" " −60 " 1 "
DJ	12.5	2	9 35.0	22 22 12	− 4 38	" " −48 " 3 "

Discovered by CHARLOIS, the first two on Aug. 25, the last on Aug. 27.

COMET *b* 1897.

A comet was discovered on Oct. 16 by PERRINE at the Lick Observatory. It is described as of the eighth magnitude, with a well-defined nucleus, a coma 2′ in diameter, and a short tail. Four positions obtained at the Lick Observatory have been communicated by telegraph as follows:—

1897 Gr. M.T.			
Oct. 16.7398	$\alpha = 3^{h}\ 36^{m}\ 7^{s}.6$	$\delta = +66^{\circ}\ 46'\ 44''$	Perrine
17.7121	30 25.7	68 17 13	Perrine
18.6498	24 2.2	69 43 54	Hussey
18.9011	22 5.5	+70 7 11	Tucker

The last of these, obtained with the meridian-circle, is subject to some doubt owing to the non-correspondence of the control-word of the dispatch with the other data.

The following orbit, computed by HUSSEY and AITKEN from the first three of the above positions, was also received by telegraph.

ELEMENTS.

$$T = 1897 \text{ Dec. } 9.23 \text{ Greenwich M.T.}$$

$$\left.\begin{aligned} \omega &= 66^{\circ}\ 28' \\ \Omega &= 32\ \ 5 \\ i &= 69\ 38 \end{aligned}\right\} 1897.0$$

$$\log q = 1.3525$$

EPHEMERIS FOR GREENWICH MIDNIGHT.

	α	δ	Br.
1897 Oct. 20.5	$3^{h}\ 7^{m}\ 56^{s}$	$+72^{\circ}\ 32'$	1.09
24.5	2 8 0	78 1	
28.5	0 2 40	81 26	
Nov. 1.5	21 23 8	80 49	1.12

This orbit and the first three positions above given were promptly circulated by Mr. RITCHIE, by circular and otherwise.

OBSERVATIONS OF COMET *b* 1897 (*PERRINE*),

MADE AT THE LICK OBSERVATORY OF THE UNIVERSITY OF CALIFORNIA,

BY C. D. PERRINE.

1897 Mt. Hamilton M.T.	✱	No. Comp.	☄ − ✱ $\Delta\alpha$	☄ − ✱ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log Δ for α	log Δ for δ
Oct. 16 9h 38m 48s	1	10 , 8	−0m 16s.35	−6′ 12″.1	3h 36m 7s.58	+66° 46′ 43″.6	*n*0.027	*n*9.914
17 8 58 49	2	11 , 8	−1 3.11	−5 52.1	3 30 25.72	+68 17 13.0	*n*0.077	*n*9.132

Mean Places for 1897.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
1	3h 36m 15s.60	+8s.33	+66° 52′ 44″.3	+11″.4	A.G. Christiania 623
2	3 31 20.12	+8.71	+68 22 53.1	+12.0	Micrometer-comparison with ✱3
3	3 34 45.68	+8.76	+68 29 28.7	+11.6	A.G. Christiania 622

OBSERVATIONS OF COMET *b* 1897,

BY J. G. PORTER.

1897 Cincinnati M.T.	✱	No. Comp.	☄ − ✱ $\Delta\alpha$	☄ − ✱ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log Δ for α	log Δ for δ
Oct. 18 9h 33m 33s	1	8	−1m 5s.73	+2′ 1″.2	3h 24m 3s.54	+69° 42′ 56″.2	*n*0.046	*n*0.190
22 8 52 27	2	8	+1 41.57	−3 26.7	2 42 6.49	+75 33 1.8	*n*0.181	*n*0.375

Mean Places for 1897.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
1	3h 25m 0s.20	+ 9s.07	+69° 40′ 42″.1	+12″.9	Christiania A.G. Catal. 604
2	2 40 13.96	+10.96	+75 36 9.7	+18.8	Bonn +75°107; Kasan A.G. Zones

OBSERVATIONS OF COMET *b* 1897 (*PERRINE*),

MADE AT THE SCHOOL OF SCIENCE OBSERVATORY, PRINCETON, N.J.,

BY TAYLOR REED.

1897 Greenwich M.T.	✱	No. Comp.	☄ − ✱ $\Delta\alpha$	☄ − ✱ $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log *p*Δ for α	log *p*Δ for δ
Oct. 18 14h 45m 16s	1	4 , 4	+2m 32s.7	+1′ 25″.1	3h 24m 14s.9	+69° 40′ 51″.4	*n*0.030	*n*0.185

Mean Place for 1897.0 of Comparison-Star.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
1	3h 21m 33s.2	+9s.0	+69° 36′ 12″.9	+13″.1	Oeltzen's Argelander 3778

$\Delta\alpha$ was measured by eye and ear transits.

Five direct comparisons with DM. +69°217 give 15h 21m 7s Gr. M.T. $\Delta\alpha$ (☄ − ✱) = −66s.4.

All measures were taken with the filar micrometer.

RESIGNATION OF THE DIRECTOR OF THE LICK OBSERVATORY.

After a continuous connection with the Lick Observatory for twenty-three years, and a service at Mount Hamilton since 1888, I have terminated my official relations with the Observatory, to take effect on December 31, 1897.

My address after October 1 will be as follows: EDWARD S. HOLDEN, *Smithsonian Institution, Washington, D.C.*

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NOTE ON DOUBLE STARS DISCOVERED AT THE HARVARD OBSERVATORY, AREQUIPA,

BY R. T. A. INNES.

In the Harvard Circular, No. 18, of 29 July last, Prof. PICKERING calls attention to a list of double stars found at Arequipa with the 13-inch refractor six years ago. I desire to record a respectful protest against the belated publication of a list of double stars in such a form. Many observers, myself amongst the number, have been devoting their time to a search for southern double stars, and we are suddenly confronted with a list of blank numbers published without particulars as to distance, angle or magnitude of the companion, beyond the general statement that the principal star is of the sixth magnitude or brighter, and that the distance is under 30″, and that those stars found in the Catalogues of HERSCHEL and RUSSELL have been excluded.

Such vague statements are very apt to be misleading, and are as a matter of fact inaccurate in particular instances.

I have drawn up a list of the positions, etc., of the stars whose numbers are recorded by Prof. PICKERING, and it will be found below. The first column gives the number (from Prof. PICKERING's list) of the star in GOULD's *Catalogo Gen. Argentina;* the second column the star's usual name; the third, its magnitude from the Harvard Southern Photometry, or, failing that source, the *C.G.A.;* the next columns give the right-ascension and south declination for 1900; and in the last column, headed remarks, the letter *T* is from Prof. PICKERING, signifying that the star is triple or multiple; it further contains any reference I have been able to find to the star as a double, if under 15″ in distance for sixth magnitude stars; beyond that distance I have not collected any notes; and the word "New" must be subject to that limitation.

An inspection of my list will show that Prof. PICKERING has included several pairs by HERSCHEL and RUSSELL, besides many pairs found years ago by other observers, including well-known stars of BURNHAM, and even a previously (1867) discovered Harvard pair.

It will be seen δ *Argus* is included as double (not triple) in this list. Now this star appears as a double in HERSCHEL's list, and I found some years ago that the chief star is itself double.* To which companion does Prof. PICKERING refer? We have no means of ascertaining whether the star is inserted as a previous discovery to that of mine in 1894 or to HERSCHEL's star.

Prof. PICKERING mentions that all stars to the limit of sixth magnitude south of −30° were examined for duplicity under very favorable atmospheric circumstances, and it might be inferred that a search with smaller telescopes within the limits assigned would be fruitless. That this is not so may be seen by reference to the lists of new pairs found here, and published in the *Astr. Nachr.*, Nos. 3419 and 3438 and elsewhere. It is also interesting to record that ψ *Argus*, found with a 6-inch on the Andes in 1884 and since seen double here, escaped rediscovery at Arequipa; but as this pair is in motion it may have been too close to have been seen in 1891.

In my sweeps with the 6.9-inch of the Cape Observatory I have, practically, examined all the brighter stars of the southern hemisphere, and am gratified, although somewhat surprised, to see the large number of double stars which were beyond my reach. Since receiving the list, I have looked at some of the new stars, but with very poor success. I find Lac. 6735 has two distant companions (11^M and 12^M, 40″ ± N.); Lac. 6793 a 10^M, 25″ S.;† P. XVI, 255, I noted but one *comes* 12^M, 12″ S. f. Lac. 7123 is a fine difficult pair, *comes* $11^M.5$, 3″ ±, 90° ±, and a 40″ star, $11^M.5$, N. f. I had swept on Lac. 6066 some months ago, when I estimated it as follows: 92° ± 1″.9, $5^M.7$ and $9^M.0$.

I feel sure astronomers will be glad to have further particulars of all the stars, and trust that Prof. PICKERING will publish them soon.

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* *M.N., R.A.S.*, Vol. LV, p. 313.

† I would not now insert these in a list of double stars. I would refer to Prof. BURNHAM's well-known opinion on this subject. If such a distance is to be included, I can only say that many of the Cape Photographic Plates that I have looked at have such pairs in the richest profusion, and the motion in all such pairs is so very slow that they may well be left for comparison with plates taken in centuries to come. It is of course possible that the stars referred to have closer companions than I could see.

SOUTHERN DOUBLE STARS FROM HARVARD CIRCULAR No. 18.

C. G. A.	Name	Mag.	1900			Remarks
			α	δ		
			h m	° ′		
451	β_1 Toucani	4.5	0 27.0	63 31	*T*	β_1 and β_2 *Toucani* = Dunlop 1. As a triple, new
480	Lac. 130	7.0	0 28.8	55 53	*T*	Old double = *h* 3376, chief star double = Innes 45
684	U.A. 64 Toucani	6.7	0 40.2	63 3		Cordoba, Vol. I. Found 1873
702	Lac. 207	5.7	0 41.1	48 6		New
780	Lac. 236	6.6	0 47.2	44 15		Innes 47
1024	β Phœnicis	3.4	1 1.6	47 15	*T*	Old double by *h*, chief star double = Sellors 1
1197	Lac. 353	5.4	1 11.6	69 21		Innes 27
2412	Lac. 717	5.4	2 16.7	56 24		New
2992	Lac. 896	5.6	2 43.3	64 8		New
3487	Lac. 1016	5.9	3 8.9	44 47	*T*	*h* 3556. Chief star double = Innes 55. Sellors or Jacob
4368	Lac. 1286	5.6	3 50.9	40 40		New
4395	Lac. 1304	6.3	3 52.0	52 59		New
4845	Lac. 1430	6.3	4 14.8	61 12		Found at Sydney
5295	α Caeli	4.5	4 37.3	42 3		New
6494	Lac. 1922	6.6	5 29.7	6 0		New
6633	α Columbae	2.7	5 36.0	34 8		New
7914	P. VI, 138	6.0	6 24.9	32 18		β 753 — originally wrongly identified as λ *Canis Majoris*
7990	Lac. 2333	5.3	6 27.3	50 10	*T*	The wide pair was noted by Dunlop; close pair is Sellors 7, also seen by Russell in 1879
8093	P. VI, 182	5.7	6 32.0	36 42	*T*	*h* 3875, chief star double = β 755
9234	Lac. 2710	5.8	7 11.9	46 41		New
10188	P. VII, 225	5.3	7 43.9	38 16		Innes 161
10335	P. VII, 250	5.0	7 48.5	34 27		Howe 9
10496	*N* Puppis	5.2	7 54.1	43 50		Triple, communicated by Prof. See
11097	*C* Carinae	5.3	8 13.8	62 36		Gilliss 91. Cape in 1875. Russell 82
11712	Lac. 2936	6.5	8 35.9	52 44		New
11727	P. VIII, 748	5.3	8 36.6	39 54		Innes 69
11887	δ Argus	2.0	8 42.0	54 20		As a double star noted by *h*, the chief star is double = Innes 10
12035	*f* Velorum	5.2	8 47.1	46 10		See *A. N.* 3419 — also previously found by Prof. See
12101	Lac. 3609	5.4	8 49.2	66 26		New
12180	*H* Velorum	4.7	8 53.3	52 20		Russell 87
13135	Lac. 3950	6.7	9 32.8	48 18		Russell 125
15795	P. XI, 105	5.6	11 28.7	40 2		Innes 78
16200	Lac. 4920	5.1	11 47.0	64 39		New
16541	η Crucis	4.3	12 1.7	64 3	*T*	New
16612	P. XII, 247	6.4	12 4.9	34 9	*T*	Jacob (1848). Howe 18. Melbourne
16690	Lac. 5066	6.5	12 8.4	33 14	*T*	Close pair = Innes 217. Third star not noticed
16793	*F* Centauri	5.0	12 13.6	54 35		New
16845	ζ_2 Muscae	5.3	12 16.6	66 58		New
16992	Lac. 5175	6.2	12 23.2	55 50		New
17403	Lac. 5278	6.3	12 41.4	32 46		New
17440	ι Octantis	5.4	12 44.4	84 35		New
17504	Lac. 5303	5.8	12 47.4	59 47		New
17541	μ Crucis	4.3	12 48.8	56 38	*T*	Dunlop 126 = 35″. Innes noted a 10^{M} at 45″ in 1895—unpub.
17572	Lac. 5321	5.6	12 50.1	56 17		New
17907	Lac. 5409	6.4	13 4.9	69 24		New
17936	Lac. 5418	4.7	13 6.0	59 23		Discovered as a close pair by Prof. See, and communicated
18174	*J* Centauri	4.6	13 16.2	60 28	*T*	New
18492	Lac. 5589	6.5	13 30.4	61 11	*T*	New
18700	*M* Centauri	4.6	13 40.4	50 56		New
18773	μ Centauri	3.3	13 43.6	41 59		New
18863	*y* Centauri	5.7	13 47.7	35 11	*T*	Close pair = Howe 25, distant *comes* = β 1108
18931	Lac. 5740	6.2	13 51.0	65 19	*T*	*Comes* at 6″ = *h* 4632 — as a triple = new
18980	Lac. 5761	6.4	13 53.3	65 47		New
19129	θ Centauri	2.2	14 0.8	35 52		Dunlop
19273	Lac. 5850	5.2	14 8.0	56 37	*T*	New
19280	Lac. 5846	5.9	14 8.7	66 7		New

C. G. A.	Name	Mag.	1900		Remarks
			α	δ	
			h m	° ′	
19295	*R* Centauri	var.	14 9.4	59 27	New
19540	Lac. 5934	6.3	14 20.8	45 41	*T* New
19578	Bris. 4918	6.3	14 22.9	67 16	*T* New
19597	Lac. 5950	5.5	14 23.7	49 4	*T* New
19679	Lac. 5969	6.5	14 26.6	52 14	New
19697	Lac. 5983	6.0	14 27.2	30 16	β 1112
19741	P. XIV, 110	6.3	14 29.2	41 5	New
19746	Lac. 5995	5.3	14 29.7	45 49	New
19873	α Lupi	2.5	14 35.2	46 57	New
19916	Lac. 6039	5.2	14 37.3	62 26	New
19934	Lac. 6057	6.2	14 38.0	55 10	*T* New
19980	Lac. 6059	6.1	14 40.3	66 10	New
19988	Lac. 6074	6.5	14 40.2	51 47	New
20049	Lac. 6066	5.6	14 43.2	72 46	92°± 1″.9± $5^{M}.7$ and $9^{M}.0$. New
20170	Lac. 6105	6.5	14 49.1	74 38	New
20203	P. XIV, 204	5.3	14 49.6	33 27	New
20444	Lac. 6209	5.3	14 58.8	40 41	*T* New
20466	*T* Triang. Austr.	var.	15 0.4	68 20	*T* New
20649	δ Circini	5.3	15 8.9	60 35	New
20695	Lac. 6272	5.4	15 10.8	60 8	New
20806	ε Lupi	3.6	15 15.9	44 20	*T* Old pair = Dunlop 182, chief star close pair noted by Copeland 1883
20811	Lac. 6308	6.5	15 16.8	67 57	New
20861	*k* Lupi	4.6	15 18.8	38 22	Quadruple with C.Z. 15^{h}1167 — see Innes 87. Nearest *comes* to *k Lupi* = 60″
20909	Lac. 6376	5.6	15 20.9	36 25	*T* New
21078	κ_2 Apodis	5.8	15 29.2	73 7	*T* New
21153	ω Lupi	4.0	15 31.3	42 14	New
21177	Lac. 6448	5.9	15 32.1	38 48	New
21319	Lac. 6477	5.8	15 38.8	65 8	*T* As a close pair = Rümker 20. As a triple, new
21374	Lac. 6521	6.5	15 41.0	37 36	New. Large proper motion
21421	Lac. 6524	5.7	15 43.3	54 45	*T* As a wide pair = Dunlop 193. As a triple, new
21499	Lac. 6546	6.1	15 47.2	59 53	*T* As a 4″ pair = *h* 4813. As a triple, new
21559	Lac. 6582	6.5	15 49.4	39 34	New
21694	ι_1 Normae	4.8	15 55.4	57 29	*T* As a close pair, communicated by Prof. See. As a wide pair = *h* 4825
21767	Lac. 6657	6.4	15 58.0	37 35	New
21828	P. XV, 255	6.5	16 0.7	36 29	New
21887	P. XV, 271	6.0	16 3.5	33 15	New
21921	κ Normae	5.1	16 5.6	54 22	New
21974	θ Normae	5.3	16 8.0	47 7	New
21995	Lac. 6735	5.4	16 8.8	53 34	New
22124	P. XVI, 37	6.3	16 13.8	39 11	Innes 91
22159	Lac. 6793	6.5	16 15.4	43 40	New
22534	Lac. 6912	6.0	16 33.8	48 34	*T* Quadruple 2″ Melbourne 1878; 9″ Innes 96, 10″ *h* 4876, others more distant
22582	Lac. 6906	5.3	16 36.6	66 55	New
22598	Lac. 6927	6.6	16 36.8	52 58	New
22604	Lac. 6946	6.4	16 37.0	37 58	New
22949	Lac. 7052	6.5	16 52.0	54 26	New
22970	Lac. 7057	6.9	16 52.8	56 24	Washburn 131
23018	ϵ_2 Arae	5.4	16 55.2	53 5	New
23035	P. XVI, 255	5.2	16 55.4	31 59	*T* New
23098	*k* Scorpii	5.0	16 58.2	33 59	New
23126	Lac. 7123	6.5	16 59.5	37 5	*T* New
23358	Lac. 7189	6.2	17 9.7	35 38	New
23397	Bris. 6022	5.5	17 11.4	46 32	*T* As a triple, new. As a close pair = Russell 297. By Cape observations, a binary in *rapid* motion
23448	Lac. 7213	6.4	17 14.3	57 55	*T* New
23486	ι Arae	5.4	17 15.8	47 23	New

C. G. A.	Name	Mag.	1900 α	1900 δ	Remarks
			h m	° ′	
23515	γ Arae	3.4	17 17.0	56 17	*T* *h* 4942. 17″ and 28″
23549	κ Arae	5.3	17 18.2	50 33	*T* New
23597	Lac. 7265	6.3	17 20.0	52 12	*T* New
23603	Lac. 7263	6.0	17 20.4	55 6	*T* New
23785	Lac. 7321	6.7	17 27.2	53 17	*T* New
23973	Lac. 7381	6.5	17 36.3	57 30	New
24148	Lac. 7419	5.7	17 42.5	60 8	New
24182	ι_2 Scorpii	4.9	17 43.1	40 4	New
24218	P. XVII, 236	6.5	17 44.5	40 45	New
24407	P. XVII, 294	5.1	17 52.7	30 15	*T* As a 5″ = *h* 5003. As a triple, new
24483	Lac. 7473	5.6	17 55.7	75 53	New
24557	Lac. 7542	6.4	17 58.1	35 54	New
24570	Lac. 7507	6.0	17 59.9	73 41	New
24624	Lac. 7540	6.5	18 1.1	59 3	New
24703	ε Telescopii	4.5	18 3.9	45 58	New
24888	η Sagittarii	3.0	18 10.9	36 48	β 760
25137	Lac. 7696	5.8	18 21.4	57 35	New
25259	P. XVIII, 79	5.5	18 24.5	33 3	Howe in 1877, β 1128
25527	Lac. 7771	6.2	18 37.4	73 6	Russell 314
25548	λ Coronae Austr.	5.2	18 36.9	38 25	New
26026	Lac. 7949	6.0	18 56.2	51 9	*T* New
26041	ζ Sagittarii	2.7	18 56.3	30 1	Harvard 150 in 1867
26287	Lac. 7997	5.6	19 7.1	66 50	Found at Sydney
27354	Lac. 8193	6.0	19 53.7	37 58	New
27909	κ_2 Sagittarii	5.7	20 17.1	42 41	β 763
28851	Lac. 8625	5.9	20 58.8	73 34	New
29314	θ_2 Microscopii	5.9	21 18.0	41 26	β 766
29368	P. XXI, 107	5.6	21 20.6	42 59	Melbourne in 1865, β 767
30425	Lac. 9076	5.4	22 11.7	54 7	New
30814	Lac. 9183	5.7	22 31.2	41 6	β 771
32446	Lac. 9721	5.6	0 1.1	49 38	New

Royal Observatory, Cape of Good Hope, 1897 *Sept.* 28.

PROVISIONAL RESULTS OF LATITUDE-OBSERVATIONS BY THE HORREBOW-TALCOTT METHOD AT THE ROYAL OBSERVATORY AT PRAGUE.

Communicated by L. WEINEK.

Herewith are presented the results of the Prague determinations of latitude from the beginning of July 1896 to the end of September 1897. Observers, Prof. Dr. L. Weinek, Dr. R. Spitaler (adjunct), and R. Leiblein.

Date	Obs.	φ	Pairs	Means	
1896		° ′ ″			″
July 6	L	50 5 15.76	11		
7	S	16.10	14		
9	L	15.79	17		
11	S	16.06	14	July 12	15.945 (106)
12	L	15.86	17		
15	L	15.99	16		
20	S	16.04	17		
Aug. 4	S	16.36	16		
14	S	16.39	8	Aug. 19	16.353 (46)
28	L	16.43	8		
Sept. 4	L	50 5 16.28	14		
1896		° ′ ″			″
Oct. 6	S	50 5 16.48	9		
8	S	16.05	17		
9	S	16.16	9		
10	L	16.07	8	Oct. 12	16.091 (77)
12	S	16.10	9		
18	S	16.00	16		
21	L	15.88	9		
Nov. 5	S	16.18	9		
6	S	16.10	12		
10	L	16.02	16	Nov. 13	15.980 (70)
13	S	15.84	9		
15	S	16.04	9		
26	W	15.77	15		
Dec. 3	W	15.96	8		
8	S	15.59	17	Dec. 8	15.747 (38)
10	S	15.82	7		
11	S	50 5 15.82	6		

Date	Obs.	φ	Pairs	Means		
1897		° ′ ″			″	
Jan. 20	L	50 5 15.50	7			
Feb. 3	S	15.51	7	Jan. 28	15.511	(15)
5	S	15.59	1			
9	S	15.95	3			
13	S	15.69	14	Feb. 17	15.802	(30)
24	S	16.16	2			
26	S	15.84	11			
Mar. 4	S	15.73	12			
16	S	15.85	12	Mar. 16	15.850	(35)
30	S	15.98	11			
Apr. 9	S	15.88	12			
14	S	16.09	6			
23	S	15.89	13	Apr. 20	15.814	(51)
26	L	15.56	9			
30	S	15.71	11			
May 3	S	16.08	12			
24	S	(14.72)	(1)			
June 1	S	15.74	7			
2	S	15.77	17	May 27	15.791	(50)
5	S	15.49	12			
8	S	50 5 16.23	2			
June 11	S	50 5 15.77	3			
12	S	15.56	12			
13	L	15.71	16			
14	S	15.79	17	June 21	15.883	(122)
23	L	15.83	13			
24	S	16.01	17			
26	S	15.95	14			
28	S	16.14	17			
30	S	16.02	13			
July 11	W	15.77	17			
12	S	15.85	8	July 12	15.804	(26)
19	S	16.02	1			
Aug. 4	S	16.24	12	Aug. 8	16.295	(24)
11	S	16.35	12			
Sept. 25	S + W	15.95	10			
26	W	16.29	17			
27	S	16.23	10	Sept. 27	16.222	(47)
29	S	16.66	2			
30	S	50 5 16.30	8			

NOTE. On Sept. 25, Group IX was observed by S., and Group I by W. (incompletely on account of clouds).

Prag, K.K. Sternwarte, 1897 *Oct.* 15.

OBSERVATIONS OF THE SATELLITES OF *SATURN*,

MADE WITH THE FILAR-MICROMETER AND 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY,

BY HERBERT R. MORGAN.

In the following observations the angles are each the mean of two comparisons, except in case of large disagreement of results, in which case more were taken. The distances were obtained by measures of double distances. Corrections have been applied for refraction. The times are Eastern Standard (75th meridian).

Enceladus–Tethys.

1897	Eastern Mean Time	*p*	Eastern Mean Time	*s*
	h m s	°	h m s	″
June 1	12 44 25	87.24	12 53 27	9.21
	13 5 43	86.34	12 57 43	9.60
6	11 59 45	297.63	12 7 52	5.79
(1)	. . .	. .	12 11 59	6.29
11(2)	10 11 27	218.45	10 25 58	5.20
	10 36 12	222.80	10 30 30	5.94
21	8 40 28	281.12	11 30 30	9.38
	11 24 18	283.80	11 35 28	9.13
	11 45 24	283.58	. . .	. .
July 2	10 33 23	128.61	10 40 46	24.04
	10 53 4	130.59	10 45 54	23.18

(1) Too faint to see longer. (2) Poor seeing.

Enceladus–Dione.

1897	Eastern Mean Time	*p*	Eastern Mean Time	*s*
July 2	11 0 24	0.10	11 7 16	18.36
	11 18 36	4.56	11 11 4	18.83
24(1)	10 1 5	19.95	10 9 55	18.83
	10 25 55	25.58	10 15 53	18.38

(1) Terribly windy.

Enceladus–Rhea.

1897	Eastern Mean Time	*p*	Eastern Mean Time	*s*
	h m s	°	h m s	′ ″
Apr. 15(1)	12 44 11	223.20	12 50 25	42.54
	13 2 11	224.58	12 55 43	42.54
July 2	11 30 34	335.36	11 39 14	27.98
	11 51 1	336.99	11 43 28	27.35

(1) Good seeing.

Tethys–Dione.

1897	Eastern Mean Time	*p*	Eastern Mean Time	*s*
Apr. 22(1)	11 47 58	301.95	. . .	. .
June 3(2)	11 29 0	136.91	11 44 53	15.98
	11 33 53	138.29	11 55 16	15.16
21(3)	11 57 13	24.16	12 5 3	18.26
	12 32 40	29.84	12 23 46	18.30
22(4)	11 20 27	75.06	11 27 39	13.80
	11 38 22	76.03	11 32 2	13.62
25(5)	11 29 32	108.51	11 35 42	1 23.68
	11 47 10	109.54	11 40 14	1 23.48
30(6)	8 59 44	45.39	9 20 41	46.77
July 30(7)	9 31 56	1.42	9 40 3	28.64
	9 52 59	7.66	9 45 11	28.49
Aug. 13(8)	8 40 27	88.05	8 47 17	1 32.35
	9 6 25	89.10	9 0 0	1 31.54

(1) Smoky. (2) Windy, cloudy. (3) Very cloudy. (4) A little windy. (5) Terribly unsteady. (6) Clouds, blurred. (7) Poor seeing. (8) Poor.

Tethys–Rhea.

1897	Eastern Mean Time	p	Eastern Mean Time	s
	h m s	°	h m s	′ ″
Apr. 13	12 1 39	77.58	12 15 1[illegible]	29.66
20	11 19 56	252.25	11 32 21	31.59
	11 24 18	252.32	11 36 8	32.40
	11 13 35	252.80	. . .	. .
June 1	13 19 10	321.13	13 24 5	31.16
	13 35 30	322.56	13 27 13	31.55
30(¹)	8 24 14	119.67	8 31 12	26.00
	8 48 44	118.75	8 41 24	26.29
July 30	10 10 23	13.86	10 18 19	40.02
Aug. 7(²)	8 36 14	308.14	8 52 39	50.99
12(³)	9 2 17	294.26	9 8 57	1 10.55

(¹) Very unsteady. (²) Windy. (³) Hazy.

Tethys–Titan.

1897	Eastern Mean Time	p	Eastern Mean Time	s
June 22(¹)	12 30 15	108.09	12 37 27	2 0.00
	12 47 57	107.59	12 40 25	2 0.07

(¹) Cloudy.

Dione–Rhea.

1897	Eastern Mean Time	p	Eastern Mean Time	s
Apr. 20(¹)	12 18 41	269.42	12 26 18	2 23.05
	12 22 4	269.77	12 30 1	2 23.33
June 3(²)	12 5 18	242.50	. . .	. .
11(³)	10 44 52	100.94	10 57 50	24.17
	10 52 0	101.14	11 6 30	24.02
	11 11 35	100.92	. . .	. .
	11 17 32	100.34	. . .	. .

(¹) Moonlight. (²) Cloudy. (³) Hazy, moonlight.

Dione–Rhea. — Cont.

1897	Eastern Mean Time	p	Eastern Mean Time	s
	h m s	°	h m s	′ ″
June 25(⁴)	11 2 27	112.49	11 7 34	18.18
	11 20 54	111.98	11 12 7	18.23
July 2	12 2 8	297.03	12 5 31	16.41
	12 17 41	296.08	12 12 48	16.46
30(⁵)	8 56 41	23.60	9 2 51	9.37
	9 15 29	23.45	9 7 22	9.44
Aug. 12(⁶)	8 30 5	50.97	8 37 7	27.05
	8 50 55	52.14	8 42 2	26.94
13	7 55 40	61.98	8 6 10	15.36
	8 18 50	62.31	8 10 57	15.27

(⁴) Hazy. (⁵) Images dancing. (⁶) Hazy.

Dione–Titan.

1897	Eastern Mean Time	p	Eastern Mean Time	s
Apr. 20	11 55 8	129.08	12 3 41	1 38.06
	11 59 28	129.08	12 8 8	1 36.55
June 22(¹)	11 53 12	112.30	12 1 22	1 47.46
	12 15 29	112.00	12 7 45	1 47.37

(¹) Images jumping.

Rhea–Titan.

1897	Eastern Mean Time	p	Eastern Mean Time	s
Apr. 22(¹)	11 24 33	216.11	11 31 16	1 51.66
	11 39 13	216.87	11 35 58	1 52.40
June 1	13 48 13	336.08	13 53 5	46.74

(¹) Very smoky.

COMPARISON OF THE CORDOBA GENERAL CATALOGUE WITH *L.O.* 310 STARS,

By R. H. TUCKER.

There are 115 stars common to the two lists, the comparison of which affords a fairly good estimate of the systematic difference. Results of previous discussions have indicated that the list observed here carries the system of the *B.J.* down to the limit of observation, −40° declination. As general confirmation of this conclusion there have also been compared the 79 stars that occur in *B.J.* and *C.G.C.* between −10 and −31°, and which, with but few exceptions, are not included in *L.O.* 310; the tabulated results are given below.

The places taken from *C.G.C.* are the means of the separate yearly results, and have been brought forward with proper motions from the standard ephemerides. In the comparison with *B.J.* the proper motions of the latter have been employed.

The direct means are as follows: (Obs. − *C.G.C.*), 114 stars, Decl. $-18^{\circ}.1$, $\Delta\alpha = +0^{s}.006$, $\Delta\delta = -0''.79$. *η Sagittarii* has been omitted from the comparison, ($\Delta\delta - 4''.1$). The probable errors of a single difference are $\pm 0^{s}.038$ and $\pm 0''.050$. There are evident systematic variations in the mean differences, depending upon right-ascension, and given in condensed form at the foot of Table I.

The direct means (*B.J.* − *C.G.C.*) are: 78 stars, Decl. $-19^{\circ}.1$, $\Delta\alpha = +0^{s}.011$, $\Delta\delta = -1''.06$. The differences for *Sirius* have been omitted. The probable errors of a single difference are: $\pm 0^{s}.039$ and $\pm 0''.45$. A similar systematic variation with right-ascension is evident.

TABLE I.

(Obs. — *Gen. Catal.*) 2-hour Groups.

R.A.	Decl.	No.	$\Delta\alpha$	$\Delta\delta$
h	°		s	″
0.8	−11.8	4	+0.012	−1.65
2.8	13.3	6	+0.013	−1.25
5.0	17.4	16	−0.004	−0.86
7.3	25.5	9	−0.047	−0.86
9.0	20.0	4	−0.025	−1.12
11.0	12.1	4	−0.020	−1.17
13.0	16.1	7	−0.041	−0.79
15.0	16.8	14	−0.011	−0.56
17.0	25.3	14	+0.018	−0.25
18.8	20.5	13	+0.040	−0.68
21.0	18.3	12	+0.039	−0.80
23.2	−14.3	11	+0.036	−0.88
Means	−17.6		+0.001	−0.91

$\Delta\alpha$ 4^{h} to 15^{h} incl. $= -0^{s}.025$
16 to 3 " $= +0.026$

$$\Delta\alpha = +0^{s}.001 - 0^{s}.04 \sin(\alpha - 4^{h})$$

$\Delta\delta$ First 12 hours $= -1''.15$
Last 12 " $= -0.66$

(*B.J.* — *Gen. Catal.*) 2-hour Groups.

R.A.	Decl.	No.	$\Delta\alpha$	$\Delta\delta$
h	°		s	″
1.5	−17.3	6	+0.053	−1.47
3.1	20.5	7	+0.037	−1.66
5.4	−18.5	8	−0.040	−0.46

R.A.	Decl.	No.	$\Delta\alpha$	$\Delta\delta$
h	°		s	″
6.8	−20.5	6	−0.023	−0.75
8.1	19.7	2	−0.095	−1.40
10.8	19.9	8	−0.016	−1.06
12.8	18.3	7	−0.024	−0.91
15.3	18.8	7	+0.023	−0.94
17.1	20.5	6	+0.023	−1.08
18.9	23.4	4	+0.050	−0.82
20.9	15.8	10	+0.052	−1.22
23.0	−20.1	7	+0.029	−1.14
Means	−19.4		+0.006	−1.08

$$\Delta\alpha \quad 4^{\mathrm{h}} \text{ to } 15^{\mathrm{h}} \text{ incl.} = -0^{\mathrm{s}}.029$$
$$16 \text{ to } 3 \quad \text{“} \quad = +0.041$$

$$\Delta\alpha = +0^{\mathrm{s}}.006 \; -0^{\mathrm{s}}.06 \; \sin(\alpha - 4^{\mathrm{h}})$$

$$\Delta\delta \quad \text{First 12 hours} = -1''.13$$
$$\text{Last 12} \quad \text{“} \quad = -1.02$$

The variation in $\Delta\alpha$ is similar in character to that found in the comparison of *L.O.* 310 and the *American Ephemeris*, upon which the right-ascensions of the *Cordoba General Catalogue* depend. This variation is as follows:

$$(\text{Obs.}-\textit{A.E.}) \quad 4^{\mathrm{h}} \text{ to } 15^{\mathrm{h}}, \quad -0^{\mathrm{s}}.040$$
$$16 \text{ to } 3, \quad -0.022$$
$$\Delta\alpha = -0^{\mathrm{s}}.031 \; -0^{\mathrm{s}}.02 \; \sin(\alpha - 4^{\mathrm{h}})$$

In Table II the results are arranged in order of declination, by groups of 10° and 5° respectively.

Lick Observatory, University of California, 1897 *Oct.* 8.

Table II.

(Obs. — *Gen. Catal.*) 10° Groups.

R.A.	Decl.	No.	$\Delta\alpha$	$\Delta\delta$
h	°		s	″
12.4	− 5.5	45	+0.002	−0.78
16.0	16.1	21	+0.001	−0.88
14.1	26.2	21	+0.021	−0.38
12.8	−35.4	27	+0.006	−1.05
Means	−20.8		+0.007	−0.77

(*B.J.* —*Gen. Catal.*) 5° Groups.

R.A.	Decl.	No.	$\Delta\alpha$	$\Delta\delta$
h	°		s	″
11.5	−12.7	20	+0.013	−1.09
13.8	16.8	25	+0.008	−1.06
11.2	22.5	20	+0.009	−1.06
12.5	−28.5	13	+0.016	−1.04
Means	−20.1		+0.011	−1.06

There does not appear to be any decided variation with declination. The catalogue-declinations depend upon determinations of the zenith-point, by nadir, and upon an invariable latitude.

As conclusion, the corrections necessary to reduce the *C.G.C.* to the *B.J.* system may be adopted as $+0^{\mathrm{s}}.01$ and $-0''.9$, with variations depending upon the right-ascension.

My long connection with the Cordoba Observatory has made this comparison a subject of special interest to me. The wealth of material which the extensive catalogue under consideration contains must render any evidence as to its place in standard star systems a desirable object of attainment.

EPHEMERIS FOR THE RETURN OF WINNECKE'S COMET,

By C. HILLEBRAND (*A.N.* 3447).

For Berlin Midnight.

1897	α	δ	log Δ	$1:r^2\Delta^2$
	h m s	° ′		
Oct. 30.5	12 24 39	+9 43.6	0.43938	0.032
Nov. 3.5	33 17	8 58.7	.42910	.034
7.5	42 8	8 13.0	.41843	.037
11.5	12 51 12	7 26.5	.40744	.041
15.5	13 0 30	6 39.0	.39613	.045
19.5	10 3	5 50.7	.38448	.049
23.5	19 53	5 1.6	.37254	.054
27.5	13 30 0	+4 11.6	0.36028	0.060
Dec. 1.5	13 40 26	+3 20.7	0.34776	0.066
5.5	13 51 12	2 28.9	.33500	.073
9.5	14 2 20	1 36.3	.32203	.082
13.5	13 52	+0 42.8	.30889	.091
17.5	25 49	−0 11.5	.29561	.102
21.5	38 14	1 6.6	.28225	.113
25.5	14 51 6	2 2.3	.26885	.127
29.5	15 4 28	−2 58.6	0.25550	0.142

OBSERVATIONS OF SOUTHERN VARIABLES IN 1885–86,

By A. STANLEY WILLIAMS.

The following estimations of the brightness of southern variable stars were made by the writer in the course of a voyage to Australia and back. The observations were made with an opera glass, the stars observed being compared with the stars of certain groups of comparison-stars selected from "Harvard Photometry." The magnitudes are therefore on the scale of the H. P. Generally two comparison-stars were employed, one a little brighter, and the other a little fainter than the star undergoing observation. As the comparison-stars were usually distant, the observations have been corrected for differential atmospheric absorption whenever sensible. In the case of the short-period variables the approximate Greenwich time of the observations is given. These times are not likely to be in error by as much as half an hour, at most.

1654 *R Doradus.* 1886 Jan. 4. $5^{M}.85$.

2583 *L^2 Puppis.*

		M
1885 Nov.	14	5.45
	15	5.35
	16	5.25
	17	5.35
	21	4.95
	24	5.1
Dec.	11	4.4
	23	3.9
	29	3.85
	31	3.6
1886 Jan.	3	3.55
	4	3.7
	25	3.9
Feb.	9	3.95
	9	(4.35)
	12	3.95
	17	3.9
1886 Feb.	21	4.1
	28	4.4
Mar.	1	4.4
	2	4.5
	5	5.0
	5	5.0
	7	5.4
	8	5.35
	10	5.35
	11	5.45
	12	5.25
	16	5.1
	17	5.3
	20	5.4
	22	5.45
	25	5.55

These observations indicate a well-defined maximum for 1886 January 10.

		h m	M
3409 *N Velorum*,	1886 Feb. 21,	3 39	3.35
	Mar. 11,	4 47	3.2

The star was probably near a maximum at the time of both these observations.

20 Hove Park Villas, West Brighton, England, 1897 *Sept.* 27.

		M
3418 *R Carinae*,	1885 Dec. 29,	5.3
	1886 Mar. 11,	5.55
3495 *l Carinae*,	1885 Nov. 21,	3.8
	Dec. 29,	3.7
	1886 Mar. 11,	4.55
	12,	3.95

4536 *R Muscae*, 1885 Dec. 31, 6^{h} 53^{m} $6^{M}.3$

The star was probably near a maximum.

(5013) *θ Apodis.* This star was announced as variable, $5^{M}.5$ to $6^{M}.6$, in the *Uranometria Argentina*, but the variability does not seem to have been confirmed yet. In 1886 it was observed as $5^{M}.2$ on Feb. 12, and $5^{M}.0$ on Feb. 14. The mean of these two observations differs by as much as $0^{M}.6$ from the S.M.P. magnitude, $5^{M}.68$. Moreover, the S.M.P. measures are very discordant, the residuals differing by more than a whole magnitude. There can be no doubt therefore of the variability of this star.

		h m	M
5319 *R Apodis*,	1886 Feb. 12,	2 24	5.6
	14,	5 23	5.0
5465 *R Triang. Aust.*,	1886 Feb. 12,	4 1	6.35
	14,	5 47	6.35
6760 *κ Pavonis*,	1886 Feb. 14,	7 22	4.7

ELEMENTS AND EPHEMERIS OF COMET *b* 1897 (*PERRINE*),

BY W. J. HUSSEY AND R. G. AITKEN.

From the observations

1897 Gr. M.T.	App. α	App. δ	Observer
	h m s	° ′ ″	
Oct. 16.73515	3 36 6.28	+66 46 42.6	Perrine
18.64514	3 24 0.48	69 43 55.9	Hussey
20.65788	3 6 21.15	+72 46 15.0	Hussey

which are already corrected for parallax and aberration, we have computed the following elements and ephemeris of this comet.

$$T = 1897 \text{ Dec. } 9.89171 \text{ Gr. M.T.}$$

$$\left.\begin{aligned} \omega &= 67^{\circ}\ \ 6'\ 55''.2 \\ \Omega &= 32\ \ \ 8\ \ 37.4 \\ \pi &= 99\ \ 15\ \ 32.6 \\ i &= 69\ \ 45\ \ 43.2 \end{aligned}\right\} \text{Ecliptic and Mean Equinox 1897.0}$$

$$\log q = 0.129500$$

$$\text{O}-\text{C}, \quad \Delta\lambda' \cos\beta' = +2''.8 \quad , \quad \Delta\beta' = +2''.4$$

Mt. Hamilton, Cal., 1897 *Oct.* 27.

CONSTANTS FOR THE EQUATOR.

$$x = r[9.937763] \sin(169^{\circ}\ 22'\ 43''.0 + v)$$
$$y = r[9.698274] \sin(169\ \ 13\ \ 28\ .3 + v)$$
$$z = r[0.000000] \sin(\ 79\ \ 20\ \ 24\ .7 + v)$$

EPHEMERIS FOR GREENWICH MIDNIGHT.

1897	True α	True δ	log Δ	Br.
	h m s	° ′ ″		
Nov. 1.5	21 22 11.00	+80 47 1.6	9.9167	1.12
5.5	19 49 14.74	77 14 27.5	9.9300	1.09
9.5	19 5 20.31	73 0 49.5	9.9162	1.04
13.5	18 42 22.86	68 54 29.5	9.9642	0.98
17.5	18 29 3.59	65 9 10.2	9.9832	0.92
21.5	18 20 45.51	61 48 10.7	0.0025	0.85
25.5	18 15 19.70	58 51 11.4	0.0214	0.79
29.5	18 11 38.97	+56 16 27.7	0.0397	0.74

The brightness at discovery is taken as unity.

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SECULAR PERTURBATIONS OF *VENUS* BY ACTION OF *MARS*,

BY ERIC DOOLITTLE.

In this computation the following elements were adopted (Dr. G. W. HILL'S "*New Theory of Jupiter and Saturn,*" pp. 192 and 554):

Venus.	*Mars.*
$\pi = 129^\circ\ 27'\ 42''.83$	$\pi' = 333^\circ\ 17'\ 51''.74$
$i = 3\ 23\ 35.01$	$i' = 1\ 51\ 2.24$
$\Omega = 75\ 19\ 53.08$	$\Omega' = 48\ 23\ 54.59$
$e = 0.00684311$	$e' = 0.09326803$
$n = 2106641''.357$	$n' = 689050''.784$
$\log a = 9.8593378$	$\log a' = 0.1828971$
$m = \frac{1}{408134}$	$m' = \frac{1}{3093500}$

Epoch 1850.0 Gr. M.T.

After the computation was completed it was duplicated from the beginning. In the duplication, the form of the equations was changed when possible, and addition and subtraction tables of logarithms were used; the usual formulas of verification were finally applied, and in addition to these such proof-equations as could be easily formed from known relations among the functions were found to be satisfied.

The results of the computation are given in the following tables, where in general the last figure of the logarithm is omitted.

$I = 1^\circ\ 56'\ 2''.46$	$\log k = p9.9998450$
$H = 208\ 26\ 43.83$	$\log k' = p9.9999075$
$H' = 52\ 18\ 22.08$	$\log c = p8.3052598$
$K = 156\ 9\ 18.63$	$c = 0.020195740$
$K' = 156\ 7\ 24.89$	

E	$\log r$	v	A	$\log B$	ϵ	g	h
°		° ′ ″			° ′ ″		
0	9.856 3557	0 0 0.00	2.651 0232	9.954 1318	150 38 56.94	0.003 928 189	2.302 46275
30	9.856 7564	30 11 47.87	2.635 6206	9.944 5723	187 50 22.82	0.000 291 101	2.302 00670
60	9.857 8493	60 20 24.50	2.676 6222	9.968 7482	224 17 18.53	0.008 527 164	2.304 04590
90	9.859 3378	90 23 31.50	2.763 0522	0.013 0109	257 33 39.62	0.020 447 915	2.306 77230
120	9.860 8213	120 20 20.31	2.871 7556	0.059 1640	287 20 29.76	0.024 164 644	2.307 62720
150	9.861 9040	150 11 43.65	2.973 6020	0.095 6658	314 29 14.61	0.015 968 474	2.305 63865
180	9.862 2996	180 0 0.00	3.041 2895	0.117 2065	340 2 26.42	0.004 037 199	2.302 74975
210	9.861 9040	209 48 16.35	3.056 6810	0.121 8001	4 56 22.54	0.000 262 374	2.302 15960
240	9.860 8213	239 39 39.69	3.015 6549	0.109 1517	30 2 36.32	0.008 368 400	2.304 56350
270	9.859 3378	269 36 28.50	2.929 2114	0.080 3244	56 13 43.77	0.020 201 647	2.307 23845
300	9.857 8493	299 39 35.50	2.820 5208	0.038 5654	84 28 16.74	0.023 896 846	2.307 39440
330	9.856 7564	329 48 12.13	2.718 7000	9.991 5602	115 46 54.47	0.015 750 931	2.305 02860
Σ_1	9.155 9964	900 0 0.00	17.076 8662	0.246 9676	1116 50 4.71	0.072 922 442	13.828 84350
Σ_2	9.155 9965	1080 0 0.00	17.076 8672	0.246 9337	936 50 17.83	0.072 922 442	13.828 84430

E	l	G	G'	G''	θ	$\log \mathfrak{K}$	$\log \mathfrak{L}$	$\log \mathfrak{N}$
°					° ′ ″			
0	0.328 36475	2.301 59781	0.334 33455	0.005 10484	22 33 26.00	0.052 36235	0.342 21622	0.253 76720
30	0.313 41820	2.301 94311	0.313 88465	0.000 40288	21 40 58.40	0.048 24440	0.336 81569	0.247 72073
60	0.352 38060	2.302 14618	0.364 44375	0.010 16345	23 44 4.25	0.058 20469	0.349 86592	0.262 32763
90	0.436 08420	2.302 01186	0.460 14840	0.019 30383	27 1 51.11	0.076 44597	0.373 65893	0.288 92064
120	0.543 93270	2.301 65423	0.568 37785	0.018 47156	30 11 38.49	0.096 71094	0.399 93150	0.318 22634
150	0.647 76765	2.301 44287	0.662 46750	0.010 47414	32 38 59.04	0.114 44649	0.422 79102	0.348 67356
180	0.718 34405	2.301 64190	0.721 88175	0.002 42983	34 6 10.10	0.125 91054	0.437 38414	0.359 89311

E	l	G	G'	G''	θ	$\log \mathfrak{K}$	$\log \mathfrak{L}$	$\log \mathfrak{N}$
210°	0.734 32570	2.302 08690	0.734 55360	0.000 15516	34° 23′ 46.69″	0.128 19869	0.440 43118	0.363 27720
240	0.690 89570	2.302 30785	0.698 35610	0.005 20478	33 30 59.53	0.121 14959	0.431 39835	0.353 24262
270	0.601 77725	2.302 07736	0.621 06785	0.014 12953	31 34 45.83	0.106 49224	0.412 55431	0.332 28403
300	0.492 93070	2.301 65418	0.518 68770	0.020 01680	28 47 46.93	0.087 40987	0.387 89402	0.301 80686
330	0.393 47570	2.301 44156	0.413 60955	0.016 54686	25 31 1.93	0.067 71795	0.362 29172	0.276 22192
Σ_1	3.126 84850	13.811 00215	3.206 08110	0.061 39126	172 54 5.30	0.541 65618	2.348 69015	1.852 26376
Σ_2	3.126 84870	13.811 00366	3.205 70155	0.061 01240	172 51 23.00	0.541 54574	2.348 54285	1.852 09808

E	$\log N$	$\log P$	Q	V	J_1'	J_2	J_3	$\log F_2$
0°	9.079 9241	8.696 1571	0.093 47591	0.093 22232	2.305 9511	+0.040 158 678	−0.039 429 682	n8.977 8486
30	9.077 8391	8.690 3136	0.091 91560	0.091 89585	2.299 9322	−0.012 465 787	−0.068 607 310	p8.412 7740
60	9.087 1721	8.708 9460	0.096 70607	0.096 18609	2.308 9846	−0.060 962 061	−0.080 069 400	p9.146 1547
90	9.105 8581	8.748 0486	0.106 91644	0.105 83577	2.318 7332	−0.093 160 848	−0.070 744 754	p9.336 0769
120	9.129 4237	8.798 3322	0.120 81990	0.119 65889	2.319 2080	−0.101 285 499	−0.043 131 936	p9.372 3426
150	9.151 6340	8.846 4806	0.135 31171	0.134 57618	2.311 9133	−0.083 189 540	−0.004 629 729	p9.282 3844
180	9.166 0121	8.878 4042	0.145 68312	0.145 49947	2.303 2761	−0.042 922 865	+0.034 445 271	p8.983 7925
210	9.168 1182	8.884 2476	0.147 65374	0.147 64185	2.299 7005	+0.009 559 512	+0.063 622 976	n8.390 2130
240	9.157 4139	8.862 5240	0.140 44699	0.140 06774	2.304 0271	+0.060 251 138	+0.075 085 208	n9.142 0736
270	9.137 3395	8.820 3390	0.127 30519	0.126 37093	2.313 5287	+0.094 787 774	+0.065 760 616	n9.333 4458
300	9.113 7453	8.770 0379	0.112 91495	0.111 73617	2.320 7257	+0.103 054 621	+0.038 147 729	n9.369 9227
330	9.092 9018	8.724 9711	0.100 92819	0.100 04980	2.317 9850	+0.082 763 214	−0.000 354 612	n9.279 4055
Σ_1	4.733 6910	2.714 4014	0.710 04694	0.706 37068	13.800 7813*	−0.001 705 675	−0.014 952 810	
Σ_2	4.733 6907	2.714 4005	0.710 03087	0.706 37038	13.800 7805*	−0.001 705 688	−0.014 952 813	

E	$\log F_3$	R_0	S_0	W_0	$\frac{1}{a}\sin E\, R^{(n)}$	$\frac{1}{a} S^{(n)}$
0°	p7.447 4916	0.063 50844	−0.000 977 0071	−0.003 536 5233	+0.000 00000	−0.001 360 0097
30	n6.655 0172	0.062 87361	+0.000 122 3535	−0.006 326 8753	+0.043 72018	+0.000 170 1610
60	n5.999 3585	0.064 61988	+0.001 299 3923	−0.007 706 6718	+0.077 63320	+0.001 802 5651
90	p7.547 9225	0.068 60530	+0.002 277 6450	−0.007 289 6438	+0.094 84620	+0.003 148 8232
120	p7.834 4086	0.074 12522	+0.002 694 3730	−0.004 731 8401	+0.088 44541	+0.003 712 2436
150	p7.813 3307	0.079 70667	+0.002 259 0820	−0.000 166 1617	+0.054 77227	+0.003 104 7600
180	p7.459 3794	0.083 40064	+0.001 035 8414	+0.005 229 4311	−0.000 00000	+0.001 422 3079
210	n6.642 4435	0.083 80114	−0.000 469 9266	+0.009 359 7858	−0.057 58587	−0.000 645 8416
240	n6.191 1157	0.080 95204	−0.001 667 1420	+0.010 505 7004	−0.096 59109	−0.002 296 9487
270	p7.534 3184	0.076 10223	−0.002 270 5920	+0.008 536 5166	−0.105 21063	−0.003 139 0719
300	p7.825 8553	0.070 80065	−0.002 287 6622	+0.004 656 8417	−0.085 05867	−0.003 173 5299
330	p7.805 1239	0.066 31737	−0.001 820 8408	+0.000 303 4394	−0.046 11486	−0.002 532 3023
Σ_1		0.437 40687	−0.000 097 7956	+0.004 416 9380	−0.015 57115	+0.000 106 6283
Σ_2		0.437 40632	−0.000 097 7209	+0.004 417 0612	−0.015 57271	+0.000 106 5284

E	$R_0 \sin v$ $+ (\cos v + \cos E)\, S_0$	$-R_0 \cos v$ $+\left(\frac{r}{a}\sec^2\varphi+1\right)\sin v\, S_0$	$W_0 \cos u$	$W_0 \sin u$	$-2\,\frac{r}{a} R_0$
0°	−0.001 954 014	−0.063 50844	−0.002 072 195	−0.002 865 834	−0.126 14768
30	+0.031 835 191	−0.054 21922	−0.000 625 404	−0.006 295 890	−0.125 00201
60	+0.057 445 987	−0.029 72268	+0.003 192 309	−0.007 014 411	−0.128 79747
90	+0.068 588 125	+0.005 02476	+0.005 936 279	−0.004 230 780	−0.137 21060
120	+0.061 265 775	+0.042 10058	+0.004 709 813	−0.000 456 037	−0.148 75771
150	+0.035 700 934	+0.071 41598	+0.000 151 409	+0.000 068 446	−0.160 35811
180	−0.002 071 682	+0.083 40064	−0.003 064 140	−0.004 237 688	−0.167 94274
210	−0.040 838 000	+0.073 18497	−0.000 988 919	−0.009 307 396	−0.168 59554
240	−0.068 190 156	+0.043 77273	+0.004 238 101	−0.009 612 920	−0.162 45809
270	−0.076 084 930	+0.005 06196	+0.006 883 205	−0.005 049 116	−0.152 20446
300	−0.063 800 118	−0.031 06656	+0.004 629 519	−0.000 503 716	−0.141 11682
330	−0.036 506 252	−0.055 49212	+0.000 277 348	+0.000 123 100	−0.131 84872
Σ_1	−0.017 304 208	+0.044 97627	+0.011 633 407	−0.024 690 606	−0.875 22051
Σ_2	−0.017 304 932	+0.044 97633	+0.011 633 918	−0.024 691 636	−0.875 21944

---

* The term G'' has been subtracted.

The equation $\sin q \,.\, \tfrac{1}{2} A_1^{(s)} + \cos q \,.\, B_0^{(c)} = 0$ was found to give the residual $+0.000,000,001,8$.

If m' is left indefinite, the resulting values of the differential coefficients are

$$\begin{array}{llll}
\left[\frac{de}{dt}\right]_{00} = & -\ \ 6075\overset{\prime\prime}{.}5972 & m' & n3.783\,5890 \\
\left[\frac{d\chi}{dt}\right]_{00} = & +2307588.8 & m' & p6.363\,1584 \\
\left[\frac{di}{dt}\right]_{00} = & +\ \ 4084.7434 & m' & p3.611\,648 \\
\left[\frac{d\Omega}{dt}\right]_{00} = & -\ 146478.61 & m' & n5.165\,7742 \\
\left[\frac{d\pi}{dt}\right]_{00} = & +2307332.0 & m' & p6.363\,1101 \\
\left[\frac{dL}{dt}\right]_{00} = & -\ 307497.75 & m' & n5.487\,8419
\end{array}$$

If the above value of m' be employed there results finally,

$$\left[\frac{de}{dt}\right]_{00} = -0\overset{\prime\prime}{.}0019639882 \qquad \left[\frac{di}{dt}\right]_{00} = +0\overset{\prime\prime}{.}0013204280$$

$$\left[\frac{d\chi}{dt}\right]_{00} = +0.74594759 \qquad \left[\frac{d\Omega}{dt}\right]_{00} = -0.047350446$$

$$\left[\frac{d\pi}{dt}\right]_{00} = +0\overset{\prime\prime}{.}71586465 \qquad \left[\frac{dL}{dt}\right]_{00} = -0\overset{\prime\prime}{.}099401232$$

These results to three significant figures have been published by NEWCOMB (*Secular Variations of the Orbits of the Four Inner Planets*, pp. 337 and 376), and also by LEVERRIER (*Annales de l'Observatoire de Paris. Memoires, Tome* VI, pp. 6 and 21). The following shows the comparison with these results; the variations have all been reduced to the above value of m'.

	LEVERRIER	NEWCOMB	Method of GAUSS
	″	″	″
$\left[\frac{de}{dt}\right]_{00} =$	-0.00195	-0.00196	-0.001964
$\left[\frac{di}{dt}\right]_{00} =$	$+0.00131$	$+0.00132$	$+0.001320$
$\sin i \left[\frac{d\Omega}{dt}\right]_{00} =$	-0.00280	-0.00281	-0.002802
$e \left[\frac{d\pi}{dt}\right]_{00} =$	$+0.00510$	$+0.00510$	$+0.005104$
$\left[\frac{dL}{dt}\right]_{00} =$	-0.099		-0.099401

The Flower Observatory, 1897 *Nov.* 6.

REMARKS ON THE REDISCOVERY OF THE COMPANION OF *SIRIUS* AND ON THE ELEMENTS OF THE ORBIT,

BY T. J. J. SEE.

The last observations of the companion of *Sirius* before periastron passage were made by BURNHAM with the 36-inch refractor of the Lick Observatory. He has recorded in the most emphatic language the difficulty of the object when last seen (1890 April 22) at a distance of 4″.19, and his chagrin at not being able to see it six months later under the most favorable atmospheric conditions, when the distance could not have been less than 3″.7. During 1896 several observers reported measures of the companion, but the latest results indicate that some of the observations relate to spurious phenomena. Among the first observations published were those of the writer in *Astronomical Journal*, No. 385; the phenomenon there discussed had every appearance of reality, and no doubt was entertained regarding the result till *Sirius* was again examined at Mexico, without disclosing any certain evidence of a companion in any of the places previously assigned. Different observers reported the companion in sensibly different places, and as I was unable to verify my own announcement or those of others, it seemed advisable to withhold further communication till the place of the companion could be assigned with certainty. The erroneous conclusion to which I was led last year seems to have arisen from a very unusual and entirely unexpected cause, of which we need not speak here; it is sufficient to say that I was guided wholly by phenomena carefully observed under good conditions, and that we did not allow our observations to be prejudiced in the least by any considerations as to the probable position of the body. When it was announced from one observatory that the body was within one degree of where I had said it ought to be and was not, I not unnaturally entertained some doubt as to the reality of the companion reported, and considered it more probable that the observers had believed that the object had a definite theoretical place, and had been misled by some spurious phenomenon. For in fact the place assigned by theory was that resulting from my own orbit, which had perhaps no better claim to authority than the orbits of AUWERS and BURNHAM, which were quite different; and gladly as I would have seen the orbit confirmed, particularly as the new work on orbits was then in the hands of the printer, I yet desired to avoid any prejudice of the facts in the case, even if the investigations in the press should all prove erroneous. My distrust of most of the results published last year was further increased by the fact that the distances reported agreed remarkably well among themselves, and yet were smaller than that at which BURNHAM had been unable to see the companion under "excellent seeing;" at the small distance of 3″.7, the angle assigned, though in exact accord with my announcement of the theoretical place (which from the use of round numbers was in error about 3 degrees), was sensibly inconsistent with the law of areas. Either the distance or the angle must be appreciably wrong, and it hardly seemed probable that, if the real object were seen, all the measures would persistently make the angles too large or the distances too small. And when it was reported that the companion had been seen with a 12-inch telescope, in a sensibly different place, the case seemed even more doubtful. Nor did the observations made at Washington in the early part of 1896 and then considered untrustworthy, but afterwards published when the Lick position was found to be inconsistent with that which I had assigned, carry conviction; for these measures had been kindly undertaken at my request, and when at Washington in April 1896, I was assured that nothing worthy of confidence had been obtained. As Professors Campbell and Hussey had been equally unsuccessful in their searches made for a like purpose about the same time, I felt that possibly the position assigned by the orbit might be entirely erroneous, and that the companion would perhaps turn up in an unexpected place. Accordingly at Mexico our search was extended over the whole region from 230° to 160°, without any result that could be depended upon; and yet the object had been followed under good atmospheric conditions on several nights for a number of hours, from the east to the west of the meridian, and therefore at a much greater altitude than was possible at any other observatory possessed of a powerful telescope. Nothing was seen but which could be explained as spurious, though it was easy to imagine that a companion was near 180°, where it had been reported, and where it was placed by my researches on the orbit. After the return of the observatory to Flagstaff there was no good opportunity to search for the companion of *Sirius* till September 25, when the seeing was extremely fine, and I got what appeared to be a genuine and unmistakable image of it, in 175°.0, 4″.55; the object was remarkably faint, and certainly could not be seen in a telescope of less than 20-inch aperture. Our subsequent measures confirm that made on Sept. 25, and give the present position of the body with the desired precision. Our observations are as follows:

t	θ_0	ρ_0	Remarks
	°	″	
1897.731	175.0	4.55	excellent measure
1897.824	173.8	4.42	
1897.826	172.8	4.81	
1897.829	173.9	4.74	good measure
1897.802	173.9	4.63	

By Mr. S. L. Boothroyd,

	°	″
1897.826	172.7	5.06
1897.829	174.6	4.84
1897.827	173.7	4.95

It is thus clear that the companion is now visible and measurable under good conditions with powerful telescopes, but there is no hope whatever of seeing it with small telescopes for several years; and the report of observations with such instruments will only indicate that the observers have been deceived. The following are all the recent measures of the object:

t	θ_0	ρ_0	n	Observers
	°	″		
1896.206	189.7	4.64	2	Brown
1896.83	189.1	3.69	3	Aitken
1896.83	189.2	3.65	2	Schaeberle
1897.18	185.4	3.88	2	Aitken
1897.206	186.6	3.78	1	Hussey
1897.214	195.0	3.5 ±	1	Pritchett
1897.747	174.9	4.00	3	Aitken
1897.802	173.9	4.63	4	See
1897.827	173.7	4.95	2	Boothroyd

In this connection it may be remarked that in April 1895 I was using the 26-inch refractor of the Leander McCormick Observatory in Virginia, and on two occasions recorded observations which now become of some interest. I searched for the companion of *Sirius* on a number of evenings, and on two occasions the small stars in the field were seen with extraordinary brilliancy. This was particularly true on April 13, when I measured and forwarded to Burnham positions of some of the objects not in any double-star work then known to me. Just after the beginning of darkness the tranquility of the air was remarkable, and it seemed that the stars shone with an unprecedented splendor; without knowing where the companion ought to be (for I had not then investigated the orbit) I set the micrometer to a faint and close image in angle 211°.2, and distant 2″.90; on the next night I resumed the search, and set on an image in 215°, and estimated the distance at 4″±. The seeing was excellent, but hardly so extraordinary as on the previous night, and having got to work a little later, a tree soon cut off the view. At the time the object did not seem to justify an announcement, yet I felt impressed with the reality of the phenomenon, and so discussed the matter with Prof. Stone and Dr. Lovett. The subsequent rains and cloudy weather cut off all hope of further search till *Sirius* was lost in the trees which stand southwest of the observatory. I should hardly make mention of this search now, except for the fact that the place then assigned proves to be extremely near the position actually occupied by the companion at that time, and it seems to me highly probable that it was seen for brief intervals on 1895 April 13.

Our recent measures, in connection with those kindly supplied by Prof. Aitken of the Lick Observatory, show that the companion of *Sirius* is following with great accuracy the orbit which I have given in the new work, *Researches on the Evolution of the Stellar Systems*, Vol. I, p. 84. It is thus made certain that this orbit has the highest degree of accuracy, and will need no improvement for twenty years, if indeed any considerable correction shall ever be required. It is probably as accurate as that of any known double star, and represents the recent reliable measures with almost absolute precision. The distance, however, has been under-measured by several recent observers, and is certainly not less than 4″.60. This we may infer from the measure on Sept. 25, and especially from the theory of the motion of the body under the law of gravitation; for the certainty attaching to the operation of gravitation in binary systems is far greater than that which could arise from a small number of even the best observations.

The following table shows the comparison of computed with observed places; and as the latest measures prove the accuracy of the orbit, the deviations from the theoretical places must be explained either by errors of observation or by the supposition that in some cases spurious phenomena were measured near the predicted place of the companion.

Comparison of Computed with Observed Places.

t	θ_o	θ_c	ρ_o	ρ_c	$\theta_o - \theta_c$	$\rho_o - \rho_c$	Observers
	°	°	″	″	°	″	
1895.286	213.2	207.9	3.45	3.70	+ 5.3	−0.25	2*n* See
1896.206	189.7	193.6	4.64	4.12	− 3.9	+0.52	Brown
1896.83	189.1	186.0	3.69	4.33	+ 3.1	−0.64	Aitken
1896.83	189.2	186.0	3.65	4.33	+ 3.2	−0.68	Schaeberle
1897.18	185.4	180.5	3.88	4.44	+ 4.9	−0.56	Aitken
1897.206	186.6	180.4	3.78	4.44	+ 6.2	−0.66	Hussey
1897.214	195.0	180.3	3.5±	4.45	+14.7	−0.95	Pritchett
1897.747	174.9	174.3	4.00	4.60	+ 0.6	−0.60	Aitken
1897.802	173.9	174.0	4.63	4.61	− 0.1	+0.02	See
1897.827	173.7	173.9	4.95	4.61	− 0.2	+0.34	Boothroyd

Ephemeris.

t	θ_c	ρ_c
	°	″
1897.70	174.5	4.59
1898.20	169.0	4.72
1899.20	158.9	4.97
1900.20	149.5	5.25

The elements of the orbit are

P = 52.20 years
T = 1893.50
e = 0.620
a = 8″.0136
☊ = 34°.3
i = 46°.77
λ = 131°.03
n = −6°.89655

Apparent Orbit.

Length of major axis = 14″.63
Length of minor axis = 9″.50
Angle of minor axis = 50°.7
Angle of periastron = 252°.4
Distance of star from center = 4″.16

The absolute dimensions of the system, resulting from these elements and Gill's parallax of 0″.38, are

Mean distance = 21.136 astronomical units
Combined mass = 3.473, sun's mass being unity

According to Auwers the masses of the components are in the ratio of 1:2.119; and hence, in units of the sun's mass, 1.113 and 2.360 respectively.

Accordingly the present state of our knowledge of this glorious system is highly satisfactory, and yet further investigation of the mass-ratio is extremely desirable. This can be effected by the use of the micrometer on some of the neighboring stars. The following measures have been made for that purpose:

AC, mag. C = 15, bluish.

t	θ_o	ρ_o	Remarks
	°	″	
1897.829	190.1	46.16	very difficult

AD, mag. D = 14.5, bluish.

t	θ_o	ρ_o
	°	″
1897.824	95.2	72.69
1897.826	94.7	73.02
1897.826	95.8	72.66
1897.825	95.2	72.79

AE, mag. E = 13.8, bluish.

t	θ_o	ρ_o
	°	″
1897.826	149.1	89.28
1897.826	149.1	89.50
1897.826	149.1	89.39

ED, mags. 13.8 and 14.5.

t	θ_o	ρ_o
	°	″
1897.826	22.8	74.49
1897.826	22.1	74.79
1897.826	22.5	74.64

AF, mag. F = 14.6, bluish.

t	θ_o	ρ_o
	°	″
1897.829	248.1	91.58

Lowell Observatory, Flagstaff, Arizona, 1897 *Nov.* 1.

ON THE COMPANIONS TO *VEGA*.

By J. M. SCHAEBERLE.

Last August, on seeing the statement in the *Astrophysical Journal*, p. 148, that Prof. Barnard had found a new distant companion to *Vega*, I examined the place with our great refractor and saw the star.

As particular attention has been called to this object in the *Astronomical Journal*, it seems desirable to announce that the star can be readily seen and measured at the Lick Observatory.

To make sure that the object seen here is identical with the one found by Prof. Barnard, I recently made two sets of micrometer-measures. One on Oct. 29, with good seeing, the other on Oct. 31, with only average seeing.

Coordinates with Reference to Winnecke's Companion.

	Position-angle	Distance
Oct. 29,	= 32°.7	= 29″.3
31,	= 32.4	= 29.2

Coordinates of Winnecke's Companion with Reference to *Vega*.

	Position-angle	Distance
Oct. 29,	= 285°.9	= 52″.9
31,	= 285.8	= 53.4

From these observations I find the coordinates of the third companion with reference to *Vega* to be

Position-angle = 317°.9
Distance = 52″.8

I had never made any search for companions at so great a distance from *Vega*, and was not even aware of the existence of Winnecke's companion (which is an easy object in the 36-inch telescope) until Prof. Barnard made some inquiries which led to my observations of this star (Winnecke's) quoted by him in No. 414 of the *Astronomical Journal*. The measures — made on a windy night with a swaying telescope — were sent to Prof. Barnard for identification.

Besides affording a test for the light-gathering power of a telescope, such a small star is also a test for the darkness of the field of view in the immediate neighborhood of a very bright object.

Lick Observatory, University of California, 1897 *Nov.* 1.

THE EFFECT UPON THE EULERIAN PERIOD OF AN INEQUALITY IN THE EQUATORIAL MOMENTS OF INERTIA,

By H. Y. BENEDICT.

In *A.J.* 345, Prof. Woodward has shown that the Eulerian period is a minimum for $A = B$; A, B and C being the principal moments of inertia of the Earth, which is supposed rigid. This may be quite easily proved in a different manner.

It is shown in Tisserand's *Mécanique Céleste*, Tome II, p. 385, that

$$\omega' \sqrt{\frac{(C-A)(C-B)}{AB}}\,(t+h) = \int_0^{\chi} \frac{d\chi}{\sqrt{1-c^2\sigma^2\sin^2\chi}}$$

where $c^2 = \dfrac{B-A}{C}$ and ω', h, and σ are constants depending on the initial circumstances of the motion. On p. 394 of the same volume it is seen that c and σ are certainly small in the case of the Earth. Now it is certainly fair to assume that c is less than either

$$\sqrt{\frac{C-B}{A}} \quad \text{or} \quad \sqrt{\frac{C-A}{B}}$$

so that the modulus of the elliptic integral is exceedingly small, less than $\sin 1''$. To a very high degree of accuracy then, the period of the Eulerian oscillation is

$$\omega' \sqrt{\frac{AB}{(C-A)(C-B)}}$$

and ω' is very nearly the angular velocity of the Earth. If no relations connect A, B and C the period may be anything whatever. Assuming that precession and the moon's motion give us

$$\frac{C-\frac{1}{2}(A+B)}{C} = \text{a constant},$$

and

$$C-\tfrac{1}{2}(A+B) = \text{a constant},$$

on differentiating we get

$$dA = -dB \quad , \quad dC = 0.$$

Differentiating $\dfrac{AB}{(C-A)(C-B)}$ for a maximum or minimum, and substituting,

$$[-AB+(C-A)(C-B)](B-A) = 0.$$

Hence either $B = A$ or $C = A+B$.

Harvard University, 8 *Divinity Hall*.

OBSERVATIONS OF D'ARREST'S COMET (*a* 1897),

MADE AT THE U.S. NAVAL OBSERVATORY (26-INCH EQUATORIAL),

BY PROF. STIMSON J. BROWN.

[Communicated by Prof. WM. HARKNESS, U.S.N., Astronomical Director.]

1897 Washington M.T.	*	No. Comp.	☄ − *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m			m s	′ ″	h m s	° ′ ″		
July 9 15 19.1	2	8 , 5	−0 4.59	−2 47.3	2 31 57.72	+6 33 55.4	*n*9.6015	0.7069
28 15 17.0	3	4 , 4	+0 11.12	−2 2.0	3 18 46.10	+6 11 48.9	*n*9.5685	0.7031
29 15 3.1	5	7 , 5	−0 14.46	−5 20.7	3 20 55.31	+6 8 27.3	*n*9.5968	0.7085
30 15 10.7	6	8 , 5	+0 13.87	−2 27.6	3 23 6.18	+6 5 7.0	*n*9.5722	0.7044
Aug. 2 15 12.0	7	8 , 5	+0 18.87	−1 35.0	3 29 27.17	+5 44 6.8	*n*9.5621	0.7067
5 15 30.0	9	7 , 4	−0 15.01	−0 1.2	3 35 33.49	+5 41 9.7	*n*9.5235	0.7012
6 15 28.0	11	9 , 5	+0 10.73	−1 40.1	3 37 31.65	+5 36 31.7	*n*9.5235	0.7019
Sept. 3 15 32.5	12	14 , 6	+0 12.82	+0 6.1	4 19 34.56	+2 21 15.8	*n*9.3348	0.7219

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	2 33 12.73	. . .	+6 30 25.94	. . .	W.B. 2^h520
2	2 32 0.32	+1.99	+6 36 26.4	+16.2	From No. 1, $-\ 1^m\ 12^s.41$ $+6'\ 0''.45$
3	3 18 31.92	+2.40	+6 13 32.8	+18.1	From No. 4, $-11^m\ 30^s.40$ $+9'\ 31''.3$
4	3 30 2.32	. . .	+6 4 1.5	. . .	W.B. 3^h507
5	3 21 7.35	+2.42	+6 13 29.8	+18.2	From No. 4, $-\ 8^m\ 54^s.97$ $+9'\ 28''.3$
6	3 22 50.17	+2.44	+6 7 16.2	+18.3	From No. 4, $-\ 7^m\ 12^s.13$ $+3'\ 14''.7$
7	3 29 5.82	+2.48	+5 55 23.4	+18.4	From No. 8, $-\ 0^m\ 15^s.02$ $-8'\ 59''.4$
8	3 29 20.84	. . .	+6 4 22.8	. . .	W.B. 3^h488
9	3 35 46.48	+2.53	+5 40 52.4	+18.6	From No. 10, $-4^m\ 25^s.51$ $-2'\ 46''.2$
10	3 40 11.98	. . .	+5 43 38.6	. . .	½ (Grant 879 + Pulk. 544)
11	3 37 18.36	+2.55	+5 37 53.3	+18.5	From No. 10, $-2^m\ 53^s.61$ $-5'\ 45''.3$
12	4 19 18.60	+3.14	+2 20 49.4	+20.3	From No. 13. $+0^m\ 14^s.15$ $+5'\ 34''.5$
13	4 19 4.45	. . .	+2 15 14.8	. . .	Boss, Albany A.G.C. 1292

On account of the unfavorable conditions in the eastern sky, caused by the glare of city lights, this comet has generally been a very difficult object, although on July 9 it could be seen in the 5-inch finder. The brightness on Sept. 3 was evidently much less than indicated by the theoretical ratio, and on subsequent dates before the full moon (on the 11th) the comet could not be seen at all.

The following corrections in R.A. have been applied to reduce to epoch of the declination: July 28, $+0^s.66$, Aug. 5, $-0^s.50$.

OBSERVATIONS OF COMET *b* 1897,

MADE AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER.

Cincinnati M.T.	*	No. Comp.	☄ − *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
1897 Oct. 25 8 8 19	1	8	−5 58.79	+0 26.7	1 42 19.02	+79 12 10.8	*n*0.265	*n*0.530

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 48 5.87	+11.94	+79 11 48.6	+25.5	1 Cincinnati Mer. Cir. observation

This star is Fedorenko 299, and appears to have proper motion as follows:

	Epoch	α 1897.0	P.M. applied	δ 1897.0	P.M. applied
		h m s	s	° ′ ″	″
Fedorenko	1790.3	1 48 1.52	6.03	+79 12 3.4	47.7
Kasan	1869.9	4.63	5.86	11 53.3	49.1
Cincinnati	97.8	1 48 5.87	5.96	+79 11 48.6	48.3
	P.M.	$+0^s.041$		$-0''.14$	

OBSERVATIONS OF COMET *b* 1897 (*PERRINE*),

MADE WITH THE 12-INCH EQUATORIAL OF THE LICK OBSERVATORY,

BY R. G. AITKEN.

1897 Mt. Hamilton M.T.		*	No. Comp.	☄ − *		☄'s apparent		log $p\Delta$	
				Δα	Δδ	α	δ	for α	for δ
	h m s			s	′ ″	h m s	° ′ ″		
Oct. 16	10 19 58	1	6	−24.80	. . .	3 35 59.13	. . .	*n*9.964	. .
	10 23 58	1	8	. . .	−3 19.7	. . .	+66 49 36.0	. .	*n*0.274
	10 30 36	1	*d*10	−27.43	. . .	3 35 56.50	. . .	*n*9.980	. .
17	12 50 35	2	*d*10, 8	−56.79	+1 52.3	3 29 21.68	+68 32 21.2	*n*9.484	*n*0.645
18	7 40 20	4	*d* 8, 8	−70.78	+3 43.6	3 23 58.49	+69 41 38.6	*n*0.132	0.204
19	8 15 21	5	*d*10, 10	+39.86	−0 49.8	3 15 44.20	+71 18 25.3	*n*0.152	8.845
20	9 44 1	6	*d*12, 5	−13.41	+2 59.0	3 5 32.84	+72 53 35.7	*n*0.193	9.729

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 36 15.61	+ 8.32	+66 52 44.3	+11.4	Fearnley, Christiania A.G. Catal. 623*
2	3 30 9.73	+ 8.74	+68 30 16.7	+12.2	Micrometer-comparison with *3
3	3 34 45.68	+ 8.76	+68 29 28.7	+11.6	Fearnley, Christiania A.G. Catal. 622
4	3 25 0.20	+ 9.07	+69 40 42.1	+12.9	Fearnley, Christiania A.G. Catal. 604
5	3 14 54.80	+ 9.54	+71 19 0.8	+14.3	Radcliffe I, 927
6	3 5 36.22	+10.03	+72 50 21.1	+15.6	Micrometer-comparison with *7
7	3 14 46.53	+10.13	+72 50 28.9	+14.4	Becker 521 stars, 79†

d signifies that Δα was measured directly with the micrometer. * No proper motion applied. † Proper motion +0s.011, −0″.057 applied.

Lick Observatory, University of California, 1897 *Oct.* 29.

OBSERVATIONS OF COMET *b* 1897,

MADE AT THE YASSAR COLLEGE OBSERVATORY,

BY MARY W. WHITNEY AND CAROLINE E. FURNESS.

Greenwich M.T.	*	No. Comp.	☄ − *		☄'s apparent		log $p\Delta$		Obs.
			Δα	Δδ	α	δ	for α	for δ	
1897 h m s			m s	′ ″	h m s	° ′ ″			
Oct. 29 16 34 36	1	5, 4	−2 39.5	−3 56.8	23 12 56.1	+81 42 10.9	0.3369	*n*0.5756	F
30 14 13 51	2	5, 6	−2 17.2	+6 8.6	22 34 57.8	+81 38 13.2	0.0049	*n*0.7260	W

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	23 15 30.7	+4.9	+81 45 31.4	+36.3	Carrington, 3580
2	22 37 12.9	+2.1	+81 31 28.0	+36.6	Carrington, 3472

Comet very faint; bisection difficult.

REQUEST FOR OBSERVATIONS OF COMET 1896 VII.

J. M. HADLEY, of Flower Observatory, University of Pennsylvania, Philadelphia, requests that any unpublished observations of Comet 1896 VII, be made public, or sent to him at an early date.

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ON INTERMEDIARY ORBITS IN THE LUNAR THEORY,

By G. W. HILL.

The difficulties investigators have met in the endeavor to push the approximation to the coordinates of a planet beyond the simple Keplerian theory, by reason that the time appeared as a multiplier outside of the trigonometrical functions, are at once removed if we consent to divide the potential function otherwise than is commonly done. This modification has given rise to what are known as intermediary orbits. But the way GYLDÉN and others have introduced them seems unnecessarily obscure, as they are often discussed without the slightest reference to the law of gravitation.

In the lunar theory much will be gained if we can make the perigee and node have a uniform motion already in the first approximation. Now the disturbing function of the solar action may be considered as involving a term which is rigorously proportional to the square of the radius and another proportional to the square of the moon's perpendicular distance from the plane of the ecliptic. The first will give rise to a movement of the perigee, while the second will impart a movement to the node.

We may then write the potential function belonging to our problem

$$\Omega = \frac{\mu}{r} + \tfrac{1}{2}\kappa(x^2+y^2) + \tfrac{1}{2}\kappa' z^2$$

where μ denotes the sum of the masses of the earth and moon and κ, κ' are two constants to be so taken that the perigee and node obtain their actual motions. Then, in considering the further effects of solar perturbation, we subtract from the ordinarily given disturbing function the terms

$$\tfrac{1}{2}\kappa(x^2+y^2) + \tfrac{1}{2}\kappa' z^2$$

The differential equations of our problem in terms of rectangular coordinates are

$$\begin{aligned}
\frac{d^2x}{dt^2} + \frac{\mu x}{r^3} &= \kappa x \\
\frac{d^2y}{dt^2} + \frac{\mu y}{r^3} &= \kappa y \\
\frac{d^2z}{dt^2} + \frac{\mu z}{r^3} &= \kappa' z
\end{aligned}$$

They admit the two integrals of conservation of areas in the plane xy and of the conservation of living forces; or, as they may be written,

$$\begin{aligned}
\frac{xdy - ydx}{dt} &= h \\
\frac{dx^2+dy^2+dz^2}{dt^2} &= 2(\Omega + C)
\end{aligned}$$

Here the time is the independent variable, but the equations to be treated are, to a considerable degree, simplified if we adopt for this the true longitude of the moon. Let, as usual, u denote the reciprocal of the moon's curtate radius, s the tangent of the latitude and v the true longitude. Then, bearing in mind that here $\frac{\partial\Omega}{\partial v} = 0$, the differential equations, usually given for these variables and the independent variable*, take the form

$$\begin{aligned}
\frac{d^2u}{dv^2} + u - \frac{1}{h^2}\frac{\partial\Omega}{\partial u} - \frac{s^2}{h^2u}\frac{\partial\Omega}{\partial s} &= 0 \\
\frac{d^2s}{dv^2} + s - \frac{s}{h^2u}\frac{\partial\Omega}{\partial u} - \frac{1+s^2}{h^2u^2}\frac{\partial\Omega}{\partial s} &= 0 \\
\frac{dt}{dv} &= \frac{1}{hu^2}
\end{aligned}$$

But $\qquad \Omega = \mu u(1+s^2)^{-1/2} + \tfrac{1}{2}\kappa u^{-2} + \tfrac{1}{2}\kappa' u^{-2}s^2$

If we substitute this value in the first and second equations of the preceding group, and, for simplicity, put $\mu = kh^2$, $\kappa = \alpha h^2$, $\kappa - \kappa' = \beta h^2$, where k, α, β are constants, we get

$$\begin{aligned}
\frac{d^2u}{dv^2} + u + \alpha u^{-3} - k(1+s^2)^{-3/2} &= 0 \\
\frac{d^2s}{dv^2} + s + \beta u^{-4}s &= 0
\end{aligned}$$

We may get rid of the constant k by substituting ku for u and then writing α for αk^{-4} and β for βk^{-4}. Thus we have

$$\left.\begin{aligned}
\frac{d^2u}{dv^2} + [1+\alpha u^{-4}]u - (1+s^2)^{-3/2} &= 0 \\
\frac{d^2s}{dv^2} + [1+\beta u^{-4}]s &= 0
\end{aligned}\right\} \quad (1)$$

---

* TISSERAND, *Mécanique Céleste*, Tom. I, p. 90.

These equations admit the integral

$$\frac{du^2+(uds-sdu)^2}{dv^2} = 2u(1+s^2)^{-1/2}-u^2+[\alpha+(\alpha-\beta)s^2]u^{-2}+C$$

Since the left member of this cannot be negative, if we construct the algebraic surface whose equation is

$$2u\,(1+s^2)^{\ 1/2}-u^2+[\alpha+(\alpha-\beta)\,s^2]\,u^{-2}+C = 0$$

the moon must move on that side of this surface for which the left member of this equation remains positive. But, for the value of the arbitrary constant C which obtains in the lunar theory, this surface will have a fold which, enveloping the origin, is closed. Moreover, for any given time, the moon will be found to be moving within this fold. This affords us an inferior limit to the value of u.

The latter of equations (1), which more especially determines s, is satisfied by the value $s = 0$. While s does not vanish in the actual lunar theory it is nevertheless quite small, and we can see that its expression has a constant factor, which if small, will render s small. Thus, in a first approximation, we can assume $s = 0$. The introduction of this value into the first of equations (1), or into the integral equation, shows that, in this approximation, v is determined as a function of u by the equation

$$(2) \qquad \frac{dv}{du} = \frac{u}{\sqrt{\alpha+Cu^2+2u^3-u^4}} = \frac{u}{\sqrt{\Delta}}$$

involving elliptic integrals. This equation has been treated by LEGENDRE* and PEIRCE†.

After the integration of this equation the resulting value of u can be substituted in the second equation of (1), and we shall have a linear differential equation of the second order with variable coefficients for determining s. This being integrated, we can substitute the resulting value of s in the first of (1), and thus a more approximate equation will be had for determining u. This alternate use of each of the equations (1) will, it is evident, give rise to an elaboration of the values of u and s of the following form: let $\tan i$ denote the small constant which factors s, i being in the neighborhood of what is known as the inclination of the lunar orbit, then

$$u = U_0+U_1\tan^2 i+U_2\tan^4 i+\ldots$$
$$s = S_0\tan i+S_1\tan^3 i+S_2\tan^5 i+\ldots$$

where the U and S will be independent of the arbitrary constant $\tan i$, save that, involving two arguments, ξ, which may be called the moon's anomaly, and η, which may be called the argument of latitude, these arguments are of the form $\xi = cv+\text{const.}$, $\eta = gv+\text{const.}$, c and g are constants which are developed in the series

$$c = c_0+c_1\tan^2 i+c_2\tan^4 i+\ldots$$
$$g = g_0+g_1\tan^2 i+g_2\tan^4 i+\ldots$$

where $c_0,\ c_1,\ \ldots\ g_0,\ g_1\ \ldots$ are independent of $\tan i$.

As to the constants α and C which appear in Eq. (2), it is plain we are not obliged to retain them, but may substitute two others for them. Let us adopt a and e, such that

$$\alpha = (1-e^2)^2(1-a)a^3 \quad , \quad C = -(3+e^2)\,a+2\,(1+e^2)\,a^2,$$

where a is a little less than unity, and e is small. Then the factors of Δ are thus shown:

$$\Delta = [a^2e^2-(u-a)^2]\,[u^2-2\,(1-a)\,u-a(1-a)\,(1-e^2)].$$

Eq. (2) can be somewhat simplified by adopting a new variable w such that $u = a\mathrm{w}$, and putting $\gamma = \frac{1-a}{a}$ which gives

$$\frac{dv}{d\mathrm{w}} = \frac{\mathrm{w}}{\sqrt{e^2-(\mathrm{w}-1)^2}\,\sqrt{\mathrm{w}^2-2\gamma\mathrm{w}-\gamma(1-e^2)}}$$

The adoption of a new variable E, such that

$$\mathrm{w} = (1+e)\cos^2\tfrac{1}{2}E+(1-e)\sin^2\tfrac{1}{2}E = 1+e\cos E,$$

produces the equation

$$\frac{dv}{dE} = \frac{\mathrm{w}}{\sqrt{\mathrm{w}^2-2\gamma\mathrm{w}-\gamma\,(1-e^2)}}$$

where, as v and E will be supposed to increase together, the radical should always receive the positive sign. In order to avoid the appearance of radicals in the expressions which follow, we adopt a new constant to replace γ such that

$$\gamma = \frac{4\delta^2}{(1-\delta^2)^2}\,(1-e^2)$$

Here e and δ are small positive quantities which may be regarded as of the first order. Then the last equation can be written

$$\frac{dv}{dE} = \frac{\mathrm{w}}{\sqrt{\mathrm{w}+\frac{2\delta}{(1+\delta)^2}(1-e^2)}\ \sqrt{\mathrm{w}-\frac{2\delta}{(1-\delta)^2}(1-e^2)}}$$

If we adopt three new constants g, h, H, such that they are determined by the equations

$$\frac{2e}{1-g} = 1+e+\frac{2\delta}{(1+\delta)^2}(1-e^2)$$
$$\frac{2e}{1-h} = 1+e-\frac{2\delta}{(1-\delta)^2}(1-e^2)$$
$$H = \frac{1+e}{2e}\sqrt{(1-g)\,(1-h)}$$

the last equation can be given the form

$$\frac{dv}{dE} = H\,\frac{1+\frac{1-e}{1+e}\tan^2\frac{1}{2}E}{\sqrt{1+g\tan^2\frac{1}{2}E}\ \sqrt{1+h\tan^2\frac{1}{2}E}}$$

This equation can be further transformed by adopting a new variable ψ to supersede E, such that

$$\tan\tfrac{1}{2}E = \frac{1}{\sqrt{g}}\tan\psi$$

**Traité des Fonctions Elliptiques*, Tom. 1, p. 561.

†Analytic Mechanics, pp. 394, 396.

And, employing the four constants k, n, f, K determined by the equations

$$k^2 = 1 - \frac{h}{g} = \frac{8\delta(1+\delta^2)e}{(1+2e\delta+\delta^2)^2 - 16\delta^2}, \qquad n = \frac{1}{g} - 1$$

$$\frac{f}{1-f} = \frac{2\delta}{(1+\delta)^2}(1-e), \qquad K = \frac{1}{\sqrt{g}}\sqrt{\frac{1-h}{1-g}}$$

the differential equation takes the form

$$dv = 2K\left[\frac{1}{1+n\sin^2\psi} - f\right]\frac{d\psi}{\sqrt{1-k^2\sin^2\psi}}$$

It will be perceived that the constants $k, n, f,$ are positive quantities of the first order of smallness, while K differs from unity by a quantity of the same order.

The form to which the equation is now reduced is that of Legendre, and it shows that the integral involves the first and third species of elliptic integrals. But we may here introduce the Θ function of Jacobi. If we put

$$\psi = am(x)$$

the differential equation takes the form

$$dv = 2K\left[\frac{1}{1+n\,sn^2x} - f\right]dx$$

Deriving the constant argument a from the equation, $(i^2 = -1)$,

$$sn^2(ia) = -\frac{n}{k^2} = \frac{g-1}{g-h}$$

we have, in terms of the Θ functions,*

$$\int_0^x \frac{dx}{1 - k^2 sn^2(ia)\, sn^2x} =$$

$$\frac{1}{\frac{d.\log sn(ia)}{d(ia)}}\left[\frac{\Theta'(ia)}{\Theta(ia)}x + \tfrac{1}{2}\log\frac{\Theta(x-ia)}{\Theta(x+ia)}\right] + x$$

But

$$\frac{d.\log sn(ia)}{d(ia)} = \frac{cn(ia)}{sn(ia)}dn(ia) = \frac{1}{\sqrt{g}}\sqrt{\frac{1-h}{g-1}} = \frac{K}{i}$$

Thus

$$\int_0^x \frac{2K\,dx}{1+n\,sn^2x} = 2i\left[\frac{\Theta'(ia)}{\Theta(ia)}x + \tfrac{1}{2}\log\frac{\Theta(x-ia)}{\Theta(x+ia)}\right] + 2Kx$$

and, putting ν for $2K(1-f)$,

$$v + \text{const.} = \left[2\frac{d\log\Theta(ia)}{da} + \nu\right]x + \frac{1}{i}\log\frac{\Theta(x+ia)}{\Theta(x-ia)}$$

The well-known periodic development of $\Theta(x)$ is

$$\Theta(x) = 1 - 2q\cos\frac{\pi x}{K} + 2q^4\cos\frac{2\pi x}{K} - 2q^9\cos\frac{3\pi x}{K} + \dots$$

For most of the applications q is so small that not more than two or three terms of this series need be considered. The constants involved have the significations

$$K = \int_0^{\frac{\pi}{2}}\frac{d\beta}{\sqrt{1-k^2\sin^2\beta}}, \qquad K' = \int_0^{\frac{\pi}{2}}\frac{d\beta}{\sqrt{1-k'^2\sin^2\beta}},$$

$$q = \epsilon^{-\pi\frac{K'}{K}}$$

As the Θ functions in our problem have complex arguments, it is necessary to separate the real from the imaginary portions. This has been done by Jacobi*, and putting $b = \frac{a}{K'}$, we have

$$\frac{d.\log\Theta(ia)}{da} =$$

$$-\frac{\pi}{K}\left\{\frac{q^{1-b}}{1-q^{1-b}} - \frac{q^{1+b}}{1-q^{1+b}} + \frac{q^{3-b}}{1-q^{3-b}} - \frac{q^{3+b}}{1-q^{3+b}} + \dots\right\}$$

And if we make

$$m = 2\frac{d\log\Theta(ia)}{da} + \nu$$

we have

$$v + \text{const.} = mx$$

$$+2\arctan\frac{q^{1-b}\sin\frac{\pi x}{K}}{1-q^{1-b}\cos\frac{\pi x}{K}} + 2\arctan\frac{q^{3-b}\sin\frac{\pi x}{K}}{1-q^{3-b}\cos\frac{\pi x}{K}} + \dots$$

$$-2\arctan\frac{q^{1+b}\sin\frac{\pi x}{K}}{1-q^{1+b}\cos\frac{\pi x}{K}} - 2\arctan\frac{q^{3+b}\sin\frac{\pi x}{K}}{1-q^{3+b}\cos\frac{\pi x}{K}} - \dots$$

This equation gives the value of v in terms of x; by the inversion of the series x can be obtained in terms of v; from which can be found $cn\,x$, and thence the value of u from the equation

$$u = aw = a\frac{1-e+[h-1+(h+1)e]\,cn^2x}{1+(h-1)\,cn^2x}$$

The employment of elliptic functions in the treatment of the problem does not appear to be an improvement, since, depending on two arguments, they cannot be tabulated to any great extent, and thus interpolation between the given values is necessarily difficult. In addition to this these functions are not so easily multiplied together as circular functions. Under these circumstances it seems the employment of periodic series throughout will have the greater advantage.

I will now show by a numerical example how much easier is the treatment by computing special values of the functions involved and thence deducing their periodic developments. It is true that this procedure demands that we know at the outset the values of the two independent constants involved. But this limitation need not greatly trouble us.

---

* Bertrand, *Calcul Intégral*, p. 653.

* *Journal für die Mathematik*, Vol. XXXIX, p. 345.

NUMERICAL ILLUSTRATION.

Let us assume the values $e = 0.055$ and $\delta = 0.1$. This value of e is about that which obtains in the actual lunar theory. The value of δ considerably exceeds that which would give the observed motion of the lunar perigee; but, by its employment, we shall better exemplify the advantages of the numerical method.

We compute to the argument E for every 30° in the semi-circumference the values of w and $\frac{dv}{dE}$ from the formulas

$$\mathrm{w} = 1 + e\cos E, \qquad \frac{dv}{dE} = \frac{\mathrm{w}}{\sqrt{\mathrm{w}^2 - 2\gamma\mathrm{w} - \gamma(1-e^2)}}$$

The computation of the latter equation will be facilitated by using the quantities θ and x derived from

$$\sin^2\theta = \frac{\gamma}{\mathrm{w}}\left(2 + \frac{1-e^2}{\mathrm{w}}\right), \qquad x = \frac{\sin^2\theta}{2\cos^2\frac{1}{2}\theta\cos\theta}$$

when $\frac{dv}{dE} = 1 + x$. The following are the values arrived at:

E	w	$\frac{dv}{dE}$
0°	1.05500 00000	1.06213 69983
30	1.04763 13972	1.06277 08524
60	1.02750 00000	1.06456 66064
90	1.00000 00000	1.06718 23976
120	0.97250 00000	1.07000 58547
150	0.95236 86028	1.07221 86201
180	0.94500 00000	1.07306 18242

From the values of $\frac{dv}{dE}$ we obtain the periodic development

$$\frac{dv}{dE} = \left\{\begin{array}{l} 1.06739\,06237 \\ -0.00545\,46813\cos E \\ +0.00020\,85064\cos 2E \\ -0.00000\,77215\cos 3E \\ +0.00000\,02807\cos 4E \\ -0.00000\,00101\cos 5E \\ +0.00000\,00004\cos 6E \end{array}\right\}$$

By integration of this and putting

$$\xi = 0.93686\,41412\,v + \text{const.},$$

we get

$$\xi = E + \left\{\begin{array}{l} -1054''.07407\sin E \\ +20.14611\sin 2E \\ -0.49737\sin 3E \\ +0.01356\sin 4E \\ -0.00039\sin 5E \\ +0.00001\sin 6E \end{array}\right\}$$

By a very easy tentative process we ascertain the values of the excess of the angle E over ξ to the argument ξ for every 30° of the semi-circumference. These, with the correspondent values of w follow:

ξ	$E - \xi$	w
0°	0''.00000	1.05500 00000
30	+512.29165	1.04756 29497
60	897.78659	1.02729 24201
90	1053.76895	0.99971 90163
120	928.00622	0.97228 59807
150	+512.53732	0.95229 64346
180	0.00000	0.94500 00000

From these special values we derive the periodic series

$$E = \xi + \left\{\begin{array}{l} 1054''.12213\sin \xi \\ -17.45483\sin 2\xi \\ +0.35334\sin 3\xi \\ -0.00704\sin 4\xi \\ +0.00016\sin 5\xi \end{array}\right\}$$

$$\mathrm{w} = \left\{\begin{array}{l} 0.99985\,94669 \\ +0.05500\,21473\cos \xi \\ +0.00014\,04918\cos 2\xi \\ -0.00000\,21465\cos 3\xi \\ +0.00000\,00413\cos 4\xi \\ -0.00000\,00008\cos 5\xi \end{array}\right\}$$

The latter expression conjoined with the equation giving ξ in terms of v may be regarded as the integral of the differential equation between w and v. It will be perceived how rapidly convergent the series is. There is here certainly no need for the introduction of elliptic functions.

Turning now our attention to the treatment of the differential equation for s, let us assume that, in the equation $\frac{d^2s}{dv^2} + \left[1 + \frac{\beta}{\mathrm{w}^4}\right]s = 0$, β has the value 0.01, nearly that which prevails in the actual lunar theory. We compute then the following special values of $\frac{\beta}{\mathrm{w}^4}$:

ξ	$\frac{\beta}{\mathrm{w}^4}$	ξ	$\frac{\beta}{\mathrm{w}^4}$
0°	0.00807 21674	120°	0.01118 98407
30	0.00830 38497	150	0.01215 93782
60	0.00897 89110	180	0.01253 92848
90	0.01001 12472		

From these special values we deduce

$$1 + \frac{\beta}{\mathrm{w}^4} = \left\{\begin{array}{l} 1.01015\,81588 \\ -0.00222\,60030\cos \xi \\ +0.00014\,72390\cos 2\xi \\ -0.00000\,92096\cos 3\xi \\ +0.00000\,03278\cos 4\xi \\ -0.00000\,00126\cos 5\xi \\ +0.00000\,00004\cos 6\xi \end{array}\right\}$$

Changing the independent variable from v to ξ we have the equation:

$$\frac{d^2s}{d\xi^2} + \left\{\begin{array}{l} 1.15089\,61649 \\ -0.00253\,61359\cos \xi \\ +0.00016\,77528\cos 2\xi \\ -0.00001\,04927\cos 3\xi \\ +0.00000\,03735\cos 4\xi \\ -0.00000\,00144\cos 5\xi \\ +0.00000\,00005\cos 6\xi \end{array}\right\} s = 0$$

To integrate this we put $\zeta = \epsilon^{\xi\sqrt{-1}}$ and assume that $s = \Sigma_i b_i \zeta^{g+i}$, i taking all integral values positive and negative. If $D = \frac{d}{d\xi}\sqrt{-1}$ the differential equation may be written $D^2 s = \Sigma_i \Theta_i \zeta^i . s$, where $\Theta_{-i} = \Theta_i$. Θ_0 is equal then to the first coefficient in the last equation written at length, but the following Θ's are equivalent to the halves of the succeeding coefficients taken in order. If we use the symbol $[i]$ to denote $(g+i)^2 - \Theta_0$, the constant coefficients b_j satisfy the equation

$$[g+j]^2 b_j - \Sigma_i \Theta_{j-i} b_i = 0$$

which holds for all integral values of j positive and negative. An abbreviated specimen of the equations the b_j satisfy is shown as follows:

$$\begin{array}{l}
\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
\ldots +[-1]\,b_{-1} - \Theta_1 b_0 - \Theta_2 b_1 - \ldots = 0 \\
\ldots - \Theta_1 b_{-1} + [0]\,b_0 - \Theta_1 b_1 - \ldots = 0 \\
\ldots - \Theta_2 b_{-1} - \Theta_1 b_0 + [1]\,b_1 - \ldots = 0 \\
\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots
\end{array}$$

All the b's but one must be eliminated from this group of equations and the result is an equation which determines g. I have given this equation previously* to a degree of approximation which more than suffices for our present purpose. Employing it, we find that $g = 1.0727978607$; that is, calling the principal argument of the latitude η, we have

$$\eta = g\xi + \text{const.} = 1.0050658465\, v + \text{const.}$$

We can now solve the group of equations determining the b's in terms of one of them, preferably b_0. The solution gives us

$$s = b_0 \Sigma_i \frac{b_i}{b_0} \epsilon^{(g+i)\xi\sqrt{-1}} + b_0' \Sigma_i \frac{b_i}{b_0} \epsilon^{-(g+i)\xi\sqrt{-1}}$$

where b_0 and b_0' are the arbitrary constants introduced by the integration. But, in place of b_0 and b_0', we substitute the arbitrary constants i and λ, such that

$$b_0 = \tfrac{1}{2}\tan i . \epsilon^{\lambda\sqrt{-1}} \quad , \quad b_0' = -\tfrac{1}{2}\tan i . \epsilon^{-\lambda\sqrt{-1}}$$

Then, η being equivalent to $g\xi + \lambda$,

$$s = \tan i\, \Sigma_i \frac{b_i}{b_0} \sin(\eta + i\xi)$$

We solve the group of equations giving the values of the $\frac{b_i}{b_0}$ by using the method of gradual approximations through recursion. Only one repetition of this is necessary to get the values of the $\frac{b_i}{b_0}$ correct to the tenth decimal. The value of s arrived at is:

$$s = \tan i \left\{ \begin{array}{ll}
-0.00000\,00004 \sin(\eta - 5\xi) & -0.00040\,30991 \sin(\eta + \xi) \\
+0.00000\,00215 \sin(\eta - 4\xi) & +0.00001\,01773 \sin(\eta + 2\xi) \\
-0.00000\,18705 \sin(\eta - 3\xi) & -0.00000\,03429 \sin(\eta + 3\xi) \\
-0.00028\,32410 \sin(\eta - 2\xi) & +0.00000\,00077 \sin(\eta + 4\xi) \\
+0.00110\,66224 \sin(\eta - \xi) & -0.00000\,00002 \sin(\eta + 5\xi) \\
+1.00000\,00000 \sin \eta &
\end{array} \right\}$$

That this series, infinite in two directions, is convergent scarcely needs demonstration.

The next step in the treatment of the problem is the determination of the part of w factored by $\tan^2 i$. The rigorous equation for w is

$$\frac{d^2\mathrm{w}}{dv^2} + \left[1 + \gamma\frac{(1-e^2)^2}{\mathrm{w}^4}\right]\mathrm{w} - (1+\gamma)(1+s^2)^{-3/2} = 0$$

or, neglecting the fourth and higher powers of s,

$$\frac{d^2\mathrm{w}}{dv^2} + \left[1 + \gamma\frac{(1-e^2)^2}{\mathrm{w}^4}\right]\mathrm{w} - (1+\gamma) + \tfrac{3}{2}(1+\gamma)s^2 = 0$$

Making ξ the independent variable and putting

$$W = \frac{[e^2 - (\mathrm{w}-1)^2][\mathrm{w}^2 - 2\gamma\mathrm{w} - \gamma(1-e^2)]}{2e^2\mathrm{w}^2}$$

$$X = -\tfrac{3}{2}\frac{1+\gamma}{e^2}\int s^2 \frac{d\mathrm{w}}{d\xi}\,d\xi$$

the integral of this equation takes the form

$$\tfrac{1}{2}\frac{d\mathrm{w}^2}{d\xi^2} = W + X$$

If w must receive the increment $\delta\mathrm{w}$ on account of X hitherto neglected, we must have

$$\frac{d\mathrm{w}}{d\xi}\frac{d.\delta\mathrm{w}}{\delta\xi} = \frac{dW}{d\mathrm{w}}\delta\mathrm{w} + X$$

But, by the theory of the variation of arbitrary constants, $\delta\mathrm{w}$ may be supposed to result from the application of a correction to the arbitrary constant which completes the value of the argument ξ. This correction can as well be supposed to be applied to ξ. Calling it $\delta\xi$, we have $\delta\mathrm{w} = \frac{d\mathrm{w}}{d\xi}\delta\xi$, and, making this substitution in the last equation, we have

$$\frac{d\mathrm{w}^2}{d\xi^2}\frac{d.\delta\xi}{d\xi} + \frac{d\mathrm{w}}{d\xi}\frac{d^2\mathrm{w}}{d\xi^2}\delta\xi = \frac{dW}{d\xi}\delta\xi + X$$

Cancelling the terms in both members of this which are equivalent, we have

$$\frac{d\mathrm{w}^2}{d\xi^2}\frac{d.\delta\xi}{d\xi} = X \quad , \quad \delta\xi = \int X\left(\frac{d\mathrm{w}}{d\xi}\right)^{-2} d\xi$$

The last gives

$$\delta\mathrm{w} = \frac{d\mathrm{w}}{d\xi}\int X\left(\frac{d\mathrm{w}}{d\xi}\right)^{-2} d\xi = -\tfrac{3}{2}\frac{1+\gamma}{e^2}\frac{d\mathrm{w}}{d\xi}\int\left(\frac{d\mathrm{w}}{d\xi}\right)^{-2}\int s^2\frac{d\mathrm{w}}{d\xi}\,d\xi^2$$

Annals of Mathematics, Vol. IX, p. 36.

As the factor $\frac{d\mathrm{w}}{d\xi}$ enters into this expression an equivalent number of times when we consider both sides of the integral signs, we can reject from it a factor which makes it small. However, this factor must be restored when we derive from the expression for $\delta\xi$ the part of it proportional to ξ, that is, the part of the motion of the perigee proportional to $\tan^2 i$.

From the preceding value of s we derive

$$-\tfrac{3}{2}\frac{1+\gamma}{e^2}s^2 = \tan^2 i\left\{\begin{array}{ll} -0.88926\,1535 & +0.00000\,0002\cos(2\eta-5\xi) \\ -0.00125\,0668\cos\xi & -0.00000\,0546\cos(2\eta-4\xi) \\ +0.00048\,6447\cos 2\xi & -0.00000\,3882\cos(2\eta-3\xi) \\ +0.00000\,3714\cos 3\xi & -0.00050\,2660\cos(2\eta-2\xi) \\ -0.00000\,0048\cos 4\xi & +0.00196\,8352\cos(2\eta-\xi) \\ & +0.88925\,9439\cos 2\eta \\ & -0.00071\,6900\cos(2\eta+\xi) \\ & +0.00017\,8311\cos(2\eta+2\xi) \\ & -0.00000\,0617\cos(2\eta+3\xi) \\ & +0.00000\,0014\cos(2\eta+4\xi) \end{array}\right\}$$

After rejecting from $\frac{d\mathrm{w}}{d\xi}$ the constant factor $-0.05500\,21473$ it becomes

$$k\frac{d\mathrm{w}}{d\xi} = \left\{\begin{array}{r} \sin\xi \\ +0.00510\,8593\sin 2\xi \\ -0.00011\,7076\sin 3\xi \\ +0.00000\,3000\sin 4\xi \\ -0.00000\,0077\sin 5\xi \\ +0.00000\,0002\sin 6\xi \end{array}\right\} = \sin\xi\left\{\begin{array}{l} 0.99988\,2847 \\ +0.01022\,3190\cos\xi \\ -0.00023\,4306\cos 2\xi \\ +0.00000\,6004\cos 3\xi \\ -0.00000\,0154\cos 4\xi \\ +0.00000\,0004\cos 5\xi \end{array}\right\}$$

If, in the periodic development of s^2, we limit ourselves to the portion independent of the argument η, we obtain, after multiplication and integration, the expression

$$-\tfrac{3}{2}\frac{k}{e^2}(1+\gamma)\int s^2\frac{d\mathrm{w}}{d\xi}\,d\xi = \tan^2 i\left\{\begin{array}{l} 0.88950\,7990\cos\xi \\ +0.00258\,4996\cos 2\xi \\ -0.00011\,4720\cos 3\xi \\ -0.00000\,0126\cos 4\xi \\ -0.00000\,0005\cos 5\xi \end{array}\right\}$$

This being multiplied by the factor $k^{-2}\left(\frac{d\mathrm{w}}{d\xi}\right)^{-2}$ there results

$$-\tfrac{3}{2}\frac{1+\gamma}{ke^2}\left(\frac{d\mathrm{w}}{d\xi}\right)^{-2}\int s^2\frac{d\mathrm{w}}{d\xi}\,d\xi = \frac{\tan^2 i}{\sin^2\xi}\left\{\begin{array}{l} -0.00910\,0625 \\ +0.89010\,8010\cos\xi \\ -0.00652\,3274\cos 2\xi \\ +0.00013\,7485\cos 3\xi \\ -0.00000\,7173\cos 4\xi \\ +0.00000\,0227\cos 5\xi \\ -0.00000\,0007\cos 6\xi \end{array}\right\}$$

For the integration which comes next in order let us put

$$\int[\gamma_0+\gamma_1\cos\xi+\gamma_2\cos 2\xi+\ldots]\frac{d\xi}{\sin^2\xi}$$
$$= [\epsilon_0+\epsilon_1\cos\xi+\epsilon_2\cos 2\xi+\ldots]\frac{1}{\sin\xi}+h\xi$$

By differentiating this equation and comparing the coefficients it will be found that

$$\begin{array}{lcl} h &=& -2\gamma_2-4\gamma_4-6\gamma_6-\ldots \\ \epsilon_0 &=& -\gamma_1-3\gamma_3-5\gamma_5-\ldots \\ \epsilon_1 &=& -\gamma_0-\gamma_2-2\gamma_4-3\gamma_6-\ldots \\ \epsilon_2 &=& \tfrac{6}{3}\gamma_3+\tfrac{10}{3}\gamma_5+\ldots \\ \epsilon_3 &=& \gamma_4+\tfrac{3}{2}\gamma_6+\ldots \\ \epsilon_4 &=& \tfrac{2}{3}\gamma_5+\tfrac{14}{15}\gamma_7+\ldots \\ \epsilon_5 &=& \tfrac{1}{2}\gamma_6+\ldots \end{array}$$

Applying these formulas it is found in the first place that $h = +0.01307\,5285\tan^2 i$. If this is multiplied by k, we shall have the portion of the motion of the perigee factored by $\tan^2 i$, which is

$$\delta e = -0.23772\,317\tan^2 i$$

The residual portion of the integral is

$$\frac{\tan^2 i}{\sin\xi}\left\{\begin{array}{l} -0.89052\,1597 \\ +0.01563\,8267\cos\xi \\ +0.00027\,5726\cos 2\xi \\ -0.00000\,7184\cos 3\xi \\ +0.00000\,0151\cos 4\xi \\ -0.00000\,0001\cos 5\xi \end{array}\right\}$$

If this is multiplied by $k\frac{d\mathrm{w}}{d\xi}$ we obtain

$$\delta \mathrm{w} = \tan^2 i \left\{ \begin{array}{l} -0.89033\,736 \\ +0.00653\,204 \cos \xi \\ +0.00056\,429 \cos 2\xi \\ -0.00001\,295 \cos 3\xi \\ +0.00000\,027 \cos 4\xi \end{array} \right\}$$

For the portion of $\delta \mathrm{w}$ which involves the argument η it is necessary to employ the linear differential equation of the second order

$$\frac{d^2 \delta \mathrm{w}}{d\xi^2} + \frac{1}{e^2}\left[1 - \frac{3\gamma(1-e^2)^2}{\mathrm{w}^4}\right]\delta \mathrm{w} + \tfrac{3}{2}\,\frac{1+\gamma}{e^2}\, s^2 = 0$$

In this we have

$$\frac{1}{e^2}\left[1 - \frac{3\gamma\,(1-e^2)^2}{\mathrm{w}^4}\right] = \left\{ \begin{array}{l} 0.99890\,38887 \\ +0.03077\,06154 \cos \xi \\ -0.00203\,53235 \cos 2\xi \\ +0.00012\,73071 \cos 3\xi \\ -0.00000\,45320 \cos 4\xi \\ +0.00000\,01744 \cos 5\xi \\ -0.00000\,00061 \cos 6\xi \end{array} \right\}$$

If we put

$$\delta \mathrm{w} = \Sigma\, k_i \cos(2\eta + i\xi)$$

$$\frac{1}{e^2}\left[1 - \frac{3\gamma(1-e^2)^2}{\mathrm{w}^4}\right] = \Theta_0 + 2\Theta_1 \cos \xi + 2\Theta_2 \cos 2\xi + \ldots$$

$$\tfrac{3}{2}\,\frac{1+\gamma}{e^2}\, s^2 = \Sigma\, H_i \cos(2\eta + i\xi)$$

$$[i] = (2g+i)^2 - \Theta_0$$

we have for finding the coefficients k_i the following group of linear equations:

$$\begin{array}{l} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \ldots + [-1]\,k_{-1} - \Theta_1 k_0 - \Theta_2 k_1 - \ldots = H_{-1} \\ \ldots - \Theta_1 k_{-1} + [0]\,k_0 - \Theta_1 k_1 - \ldots = H_0 \\ \ldots - \Theta_2 k_{-1} - \Theta_1 k_0 + [1]\,k_1 - \ldots = H_1 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \end{array}$$

These equations being solved we obtain

$$\delta \mathrm{w} = \tan^2 i \left\{ \begin{array}{l} -0.00000\,007 \cos(2\eta - 6\xi) \\ +0.00000\,227 \cos(2\eta - 5\xi) \\ -0.00010\,285 \cos(2\eta - 4\xi) \\ -0.01836\,848 \cos(2\eta - 3\xi) \\ +0.00407\,911 \cos(2\eta - 2\xi) \\ -0.29855\,849 \cos(2\eta - \xi) \\ -0.29386\,799 \cos 2\eta \\ -0.00043\,539 \cos(2\eta + \xi) \\ +0.00000\,630 \cos(2\eta + 2\xi) \\ -0.00000\,070 \cos(2\eta + 3\xi) \\ +0.00000\,002 \cos(2\eta + 4\xi) \end{array} \right\}$$

It will be perceived that this infinite series is amply convergent for practical purposes. The presence of the small divisors $[-3] = -0.019\ldots$ and $[-1] = +0.021\ldots$ has the effect of making the coefficients of the arguments $2\eta - 3\xi$ and $2\eta - \xi$ abnormally large in the series of coefficients, but the ratio of decrement in the coefficients is scarcely influenced by this circumstance.

The next step in the elaboration of the subject would be the determination of the change δs in s which is caused by taking into account the portion of w factored by $\tan^2 i$. Here we should have to deal with the linear differential equation

$$\frac{d^2 \delta s}{dv^2} + \left[1 + \frac{\beta}{\mathrm{w}^4}\right]\delta s = \frac{4\beta}{\mathrm{w}^5}\, s\,\delta \mathrm{w}$$

But enough has been done to show the practical advantage of retaining periodic series involving circular functions.

ON THE WORTHLESSNESS OF A PROPOSED FORM OF TELESCOPE,

BY J. M. SCHAEBERLE.

How completely certain fundamental principles of optics have remained hidden ever since the invention of the telescope is perhaps best illustrated by the suggestions, made at various times, to construct a reflecting telescope in which the mirror is a portion of a paraboloid of revolution cut from the surface near the extremity of the *latus rectum*. The reflected rays then being at right-angles to the incident rays, no dome would be required for such a telescope, and there would be no secondary mirror.

This form of telescope was recommended by Professor PICKERING more than sixteen years ago (see *Nature* for August 25, 1881). In the *Johns Hopkins Circular* for June, 1897, Professor C. L. POOR advocates the construction of such a telescope and, according to the reports of the dedication exercises of the Yerkes Observatory, Dr. POOR on that occasion exhibited such a mirror constructed by himself.

To show the utter uselessness of such an instrument only a few approximate computations need be made. Let L denote the distance from the focus to the center of the mirror which is evidently inclined about 45° to the line of sight. If D denotes the minimum diameter of this elliptical mirror the maximum diameter must be $D \sec 45°$ if a circular cone of rays is to be used.

The linear distances from the focus to the nearest and most distant points of the mirror will then be approximately

$$\begin{array}{ll} \text{Least distance} & = L - \tfrac{1}{2} D \sec 45° \\ \text{Greatest distance} & = L + \tfrac{1}{2} D \sec 45° \end{array}$$

If we assume $\dfrac{L}{D} = \dfrac{7}{1}$ the greatest distance divided by the least distance becomes 1.22.

This quantity is approximately the *blurring factor* for the given ratio of focal length to aperture for this form of instrument. For a star which is, say only 5′ from the optical axis of the telescope, and in a place containing the longer axis of the mirror, the image will, therefore, not be a point, but rather a line of light, the length of the line being no less than 66″, or more than a minute of arc! Exactly at the focal point this star-image will be a point, but for all other positions of the image the definition will be worthless.

These considerations are but special applications of my results given in No. 413 of the *Astr. Journal.*

Further illustrations seem to be unnecessary.

Lick Observatory, University of California, 1897 *Oct.* 29.

ELEMENTS AND EPHEMERIS OF COMET *b* 1897 (*PERRINE*),*

By C. D. PERRINE.

The following system of elements has been deduced from the Mt. Hamilton observations of October 16, 24 and 31. The observation of the 16th is the discovery position; those of the 24th and 31st depend each upon the mean of two observations by Professor Hussey and myself, made within an hour of each other.

Elements.

$$T = 1897 \text{ December } 8^d.84714 \text{ Gr. M.T.}$$

$$\left.\begin{aligned} \omega &= 66^\circ\ 5'\ 42''.2 \\ \Omega &= 32\ \ 4\ \ 4.9 \\ i &= 69\ 37\ 40.9 \end{aligned}\right\} \text{Ecliptic and Mean Equinox of 1897.0}$$

$$\log q = 0.132056$$

Residuals, O—C, $\Delta\lambda' \cos\beta'$ $+4''.1$, $\Delta\beta'$ $+4''.3$.

Ephemeris for Greenwich Mean Midnight.

1897	True α	True δ	log *r*	log Δ	Br.
	h m s	° ′			
Nov. 29.5	18 12 28	+56 34.0	0.134	0.041	0.72
Dec. 1.5	11 4	55 25.1			
3.5	9 54	54 21.0	0.133	0.058	
5.5	8 56	53 21.3			
7.5	8 5	52 25.9	0.132	0.074	0.63
9.5	7 22	51 34.3			
11.5	6 45	50 46.6	0.132	0.089	
13.5	6 14	50 2.4			
15.5	5 46	49 21.3	0.133	0.103	0.55
17.5	18 5 21	+48 43.3			
Dec. 19.5	18 4 59	+48 8.4	0.135	0.116	
21.5	4 38	47 36.3			
23.5	4 18	47 7.0	0.138	0.127	0.48
25.5	4 0	46 40.2			
27.5	3 40	46 15.8	0.141	0.137	
29.5	3 20	45 53.5			
31.5	18 3 0	+45 33.9	0.145	0.145	0.43

Constants for the Equator of 1897.0.

$$\begin{aligned} x &= r[9.938189] \sin(v + 168^\circ\ 23'\ 55''.1) \\ y &= r[9.696992] \sin(v + 167\ 58\ 32.6) \\ z &= r[9.999999] \sin(v + \ 78\ 17\ 37.8) \end{aligned}$$

The comet's appearance has changed considerably since discovery. For the first few days it had a sharply defined stellar nucleus fully as bright as 12^M and a decided condensation; and was easily visible in bright moonlight with the 12-inch telescope and power of 150. At the time of my last observation, on Oct. 31, there was no stellar nucleus and no condensation at the head — the comet presenting the appearance of a streak of nebulosity of almost uniform brightness about 3′ long, followed by a fainter streak of 2′ length, and was much fainter and more difficult to measure owing to the absence of any well defined spot in the head upon which to set the wires. There was but little change in size to be detected.

Lick Observatory, University of California, Mt. Hamilton, 1897 *Nov.* 6.

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* *From Supplement to* No. 418.

MERIDIAN-CIRCLE OBSERVATION OF COMET *b* 1897,*

By R. H. TUCKER.

1897	Green. m. date	App. α	App. δ
		h m s	° ′ ″
October 18	18.9011	3 22 5.51	+70 7 11.2

Lick Observatory, University of California, 1897 *Nov.* 6.

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* *From Supplement to* No. 418.

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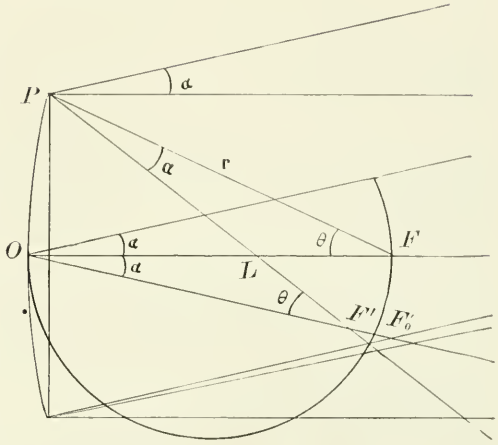
THE ABERRATION OF PARABOLIC MIRRORS,

By CHARLES LANE POOR.

For some months I have been experimenting with parabolic mirrors for reflecting telescopes, being especially interested in attempts to grind and polish a new form of mirror, which promised, apparently, many distinct advantages over the ordinary form. These experiments led to an investigation of the theory of the optical properties of different portions of a paraboloid of revolution. To my knowledge, no satisfactory investigation of these properties has hitherto been published. Astronomers and instrument makers have been satisfied with the fact that one portion of the field is theoretically perfect; and have assumed, apparently, that the field is sensibly flat, and that the aberrations in different portions are insensible. These latter are very far from being the facts, as is admirably pointed out in the paper by Prof. SCHAEBERLE, in *Astronomical Journal*, No. 413. The formulas contained in Professor SCHAEBERLE's paper are approximate, and are derived in an approximate, and somewhat obscure, manner. I have, therefore, put some of my results in shape, and give them in the following paragraphs. These formulas are rigorously derived, and are accurate. They give rise to several interesting theorems, concerning the field of a reflector and the various foci of different portions of the mirror. In the present article I have confined myself to the formulas relating to, and the properties of the central portion of the paraboloid; that portion which forms the mirror of all reflecting telescopes now in use.

Let the following figure represent a section of the paraboloid; OF being its axis, and F the focus. Further let

P, be any point of the surface.
r, the radius vector drawn to this point.
x, y, the rectangular coordinates of P.
f, the focal length of the parabola.
θ, the half angular aperture of the mirror.



Now, suppose a beam of light be incident on the surface making an angle, α, with the axis of the paraboloid. The central ray of this beam is incident at O, and is reflected in the direction OF'; the ray incident at P intersects this central ray at F'; call f' the distance OF'. This distance will vary as P moves along the parabola, and is therefore a function of θ, as well as of α. A general expression for it may be derived as follows:

We have the following general relations,

$$\sin\theta = \frac{y}{r} \tag{1}$$

and from the theory of the parabola,

$$r = \frac{f}{\cos^2 \frac{1}{2}\theta} \tag{2}$$

Combining these we find

$$(3)\qquad y = \frac{f\sin\theta}{\cos^2\frac{1}{2}\theta} = 2f\tan\tfrac{1}{2}\theta$$

From the figure we have in the triangle OLF'

$$(4)\qquad f' = OL\,\frac{\sin(\theta+\alpha)}{\sin\theta}$$

But, $\quad OL = x + y\cot(\theta+\alpha)$

The equation of the generating parabola is

$$y^2 = 4fx$$

whence, substituting,

$$OL = \frac{y^2}{4f} + y\cot(\theta+\alpha)$$

Substitute the value of OL in (4), and reduce the result by means of (3) and we shall finally obtain

$$(5)\qquad f' = \frac{f}{\cos^2\frac{1}{2}\theta}\left[\cos(\theta+\alpha) + \tfrac{1}{2}\tan\tfrac{1}{2}\theta\sin(\theta+\alpha)\right]$$

and this is a rigorous expression for f' and shows it to be a function of θ and α.

If in this formula we put α equal to zero, the expression for f' reduces to $f' = f$, an expression independent of θ, and thus shows that all the rays are brought rigorously to a single focus when the incident light is parallel to the axis of figure. This, of course, is the ordinary well known property of the parabola.

If we put θ equal to zero, our general formula reduces to

$$(6)\qquad f_0' = f\cos\alpha$$

That is, as the angular aperture of the mirror is reduced, the focal length for oblique rays tends to the above, f_0', as a limit, and the locus of f' as α takes different values, is therefore the field of the mirror.

Equation (6) is the polar equation of a circle with f as diameter; hence the field of the mirror is spherical and the diameter of the sphere is the focal length of the mirror.

As the triangles PFL and OLF' are similar, the four points, O, P, F and F' lie on the circumference of a circle. This gives the following interesting theorem:

For incident light, oblique to the axis, the intersection of the central ray with the ray from any point, P, of the parabola, lies on the circumference of a circle passing through the centre of the mirror, the principal focus, and the reflecting point, P, of the parabola.

The aberration in different portions of the field may be rigorously found, as follows:

For oblique light the linear aberration in the direction of the central ray will be $\Delta f' = f' - f_0'$. Substituting in this the values of f' and f_0' as above given, we have

$$\Delta f' = \frac{f}{\cos^2\frac{1}{2}\theta}\left[\cos(\theta+\alpha) + \tfrac{1}{2}\tan\tfrac{1}{2}\theta\sin(\theta+\alpha) - \tfrac{1}{2}\cos\alpha(1+\cos\theta)\right]$$

Expanding the cosine and sine of $\theta+\alpha$ and reducing, this expression takes the form

$$\Delta f' = -\frac{f}{\cos^2\frac{1}{2}\theta}\left[\sin\alpha\sin\theta - \tfrac{1}{2}\tan\tfrac{1}{2}\theta\cos\theta\sin\alpha\right]$$

Factoring out $\sin\alpha$, this may be put in the form

$$\Delta f' = -f\sin\alpha\tan\tfrac{1}{2}\theta\left[1 + \frac{1}{2\cos^2\frac{1}{2}\theta}\right] \qquad (7)$$

which is a rigorous expression for the linear aberration of an oblique ray. In this we may introduce the half aperture, y, by the relation $y = 2f\tan\frac{1}{2}\theta$ and we have for the final expression for the linear aberration

$$\Delta f' = -\tfrac{1}{2}y\sin\alpha\left[1 + \frac{1}{2\cos^2\frac{1}{2}\theta}\right] \qquad (8)$$

A very close approximate expression for the aberration can be derived by putting, in the above rigorous formula, $\cos\frac{1}{2}\theta$ equal to unity. We then have

$$\Delta f' = -\tfrac{3}{4}\,y\sin\alpha \qquad (9)$$

The rays from the upper portion of the parabola come to a shorter focus than do those from the lower portion.

Now, let σ represent the transverse linear aberration at the point where it is smallest, that is, in the spherical field. Then from the figure we have

$$\sigma = \Delta f'\tan\theta$$

The injurious effect of the aberration is proportional to the angle which σ subtends at the center of the mirror, and calling this angle, γ, we have, finally,

$$\tan\gamma = \frac{\sigma}{f_0'} = \frac{\Delta f'}{f_0'}\tan\theta$$

Substituting in this the values of f_0' and $\Delta f'$ we have

$$\tan\gamma = -\tfrac{1}{2}\frac{y}{f}\tan\alpha\tan\theta\left[1 + \frac{1}{2\cos^2\frac{1}{2}\theta}\right]$$

which is the rigorous expression for the injurious effect of the aberration. But as γ is a very small angle we may replace the tangent by the arc itself, and our final and rigorous formula becomes

$$\gamma = -\tfrac{1}{2}\cdot\frac{y}{f}\cdot\frac{\tan\alpha\tan\theta}{\tan 1''}\left[1 + \frac{1}{2\cos^2\frac{1}{2}\theta}\right] \qquad (10)$$

A very convenient and close approximation to the above may be made by putting $\cos^2\frac{1}{2}\theta = 1$ and $\tan\theta = \frac{y}{f}$.

We then have

$$\gamma = -\tfrac{3}{4}\frac{y^2}{f^2}(\alpha)'' \qquad (11)$$

when the angle α is expressed in seconds of the arc.

Conclusion. The image of a faint star situated at an angle α from the center of the field, will be a disc whose diameter is γ, as given by equation (10) or by the approximate form (11). The size of the star-disc is directly proportional to its angular distance from the center of the field, and approximately proportional to the square of the aperture, and inversely proportional to the square of the focal length of the mirror.

As we have seen, the true field of a parabolic mirror is spherical, while the field as used for photography, or for visual purposes, is plane. Hence, even if the star images in the true field be points of light, their projections on the photographic plate will be discs. The images in the true field are discs, and these will therefore be enlarged before they reach the flat plate. This effect, however, will be very small in comparison to the aberration as above discussed. In every case, however, the curvature of the field increases the size of the discs, and the injurious effect is slightly increased.

The annexed table shows the results as obtained above, and applied to reflectors of different proportions. The first column gives the ratio of aperture to focal length; the next three columns the size of a star-disc on the field of least aberration for various distances from the center of the field; and the final column gives the real size of a star-disc, as it would appear on a photographic plate, distant 1° from the center. This column contains the combined effect of aberration and curvature of field.

TABLE.

Aperture Focal Length		Aberration		Star-Disc
	5′	30′	1°	1° from center
	″	″	″	″
$\frac{1}{5}$	2.3	13.5	27.0	33.3
$\frac{1}{6}$	1.6	9.4	18.7	23.9
$\frac{1}{7}$	1.1	6.8	13.7	18.2
$\frac{1}{8}$	0.9	5.3	10.5	14.4
$\frac{1}{10}$	0.6	3.4	6.7	9.8
$\frac{1}{12}$	0.4	2.3	4.7	7.3
$\frac{1}{15}$	0.25	1.5	3.0	5.1
$\frac{1}{20}$	0.14	0.8	1.7	3.2

From the above table we see that in the superb reflector of ISAAC ROBERTS, Esq., the disc of a star 1° from the center of the field, would exceed half a minute in diameter. These results agree very closely with the approximate ones derived by SCHAEBERLE. But on account of the curvature of the field his results are in every case too small, and he therefore underestimates the injurious effect of the aberration.

OBSERVATIONS OF THE BINARY SYSTEMS OF *SIRIUS*, *PROCYON* AND 85 *PEGASI* (β 733),

BY J. M. SCHAEBERLE.

Sirius.

	°	″
1897 Oct. 18	176.7	3.92
Nov. 1	174.5	3.95
Nov. 15	174.3	3.99
Mean 1897.839	175.17	3.95

The Editor has kindly sent me the advance sheets of Dr. SEE's singularly strange article on "Remarks on the Rediscovery of the Companion of *Sirius* and on the Elements of the Orbit" (*A.J.* 418). I have no comments to make, except to state that the Lick Observatory observations are correct within the limits of the probable errors of observation.

Procyon.

	°	″
Oct. 8	324.1	4.70
17	323.0	–
18	323.8	4.76
29	324.2	4.51
30	326.2	4.59
Nov. 1	324.3	4.67
15	325.2	4.71
Mean 1897.821	324.40	4.66

Lick Observatory, University of California, 1897 *Nov.* 16.

The companion to *Procyon* has finally been seen at two other observations. Dr. SEE of the Lowell Observatory writes, that on the first of the present month he and his assistant, Mr. BOOTHROYD, saw and measured the companion.

Professor BARNARD writes, that on the third of the present month the companion "was clearly and distinctly seen" with the great refractor of the Yerkes Observatory during a few moments of steadiness, but that before he could measure it the seeing became bad again.

So far as I know these are the only observations of *Procyon's* companion made away from Mt. Hamilton.

85 *Pegasi* (β 733).

	°	″
July 3	211.3	0.85
5	214.3	0.81
9	210.6	0.86
10	213.5	0.83
12	211.0	0.76
Aug. 27	213.5	0.79
Sept. 13	210.8	0.73
Oct. 11	214.9	0.67
Mean 1897.593	212.49	0.79

OBSERVATIONS OF MINOR PLANET (194) *PROKNE*,

MADE AT WINDSOR, N.S. WALES,

BY JOHN TEBBUTT.

1897 Windsor M.T.		✱	No. Comp.	Planet — ✱		Planet's Apparent		log $p\Delta$	
				$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Aug. 15	9 14 55	1	15	−3 43.67	− 2 53.5	22 33 56.95	− 3 2 28.7	*n*9.564	*n*0.663
	9 44 55	2	15	−3 45.18	. . .	22 33 56.91	. . . .	*n*9.564	. .
16	10 44 56	3	10	+7 25.17	+ 5 5.0	22 33 28.27	− 3 20 53.5	*n*9.416	*n*0.653
17	10 9 51	3	10	+6 57.61	−12 15.6	22 33 0.72	− 3 38 14.0	*n*9.498	*n*0.653
	10 9 51	4	10	+2 43.54	. . .	22 33 0.69	. . . .	*n*9.498	. .
18	9 31 35	5	10	−3 0.38	+ 9 21.2	22 32 31.95	− 3 55 40.3	*n*9.565	*n*0.655
	9 31 35	6	10	−4 18.96	+ 4 38.4	22 32 31.76	− 3 55 40.7	*n*9.565	*n*0.655
19	9 31 9	5	12	−3 30.34	− 8 50.0	22 32 2.01	− 4 13 51.4	*n*9.558	*n*0.652
	9 31 9	6	12	−4 48.87	. . .	22 32 1.86	. . . .	*n*9.558	. .
23	9 40 43	7	10	+4 45.67	− 7 55.2	22 29 55.57	− 5 28 18.9	*n*9.504	*n*0.635
26	8 57 28	8	10	−3 42.57	+11 2.4	22 28 18.21	− 6 24 34.2	*n*9.564	*n*0.632
	8 57 28	9	10	−4 18.50	+11 29.3	22 28 17.93	− 6 24 35.3	*n*9.564	*n*0.632
29	8 55 15	10	20	+0 39.52	−17 31.0	22 26 37.76	− 7 21 55.6	*n*9.544	*n*0.619
30	9 18 15	11	10	+4 49.49	+12 17.4	22 26 3.86	− 7 41 21.5	*n*9.486	*n*0.607
31	8 45 5	11	10	+4 17.50	− 6 22 7	22 25 31.87	− 8 0 1.5	*n*9.547	*n*0.613
Sept. 2	9 36 13	12	16	−0 46.83	− 0 31.5	22 24 25.44	− 8 38 41.5	*n*9.398	*n*0.586
4	8 56 45	13	12	+1 56.97	−14 4.7	22 23 23.05	− 9 15 47.7	*n*9.485	*n*0.588
10	9 18 38	14	10	−4 17.59	+ 6 47.6	22 20 28.62	−11 5 7.7	*n*9.337	*n*0.545
13	8 53 18	15	15	−2 3.20	−11 48.5	22 19 14.66	−11 56 31.5	*n*9.384	*n*0.535

Mean Places for 1897.0 of Comparison-Stars.

✱	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	22 37 36.52	+4.10	− 2 59 57.4	+22.2	Lalande 44422
2	22 37 38.29	+4.10	. . . .	. .	Lalande 44423
3	22 25 58.96	+4.14 +4.15	− 3 26 20.2	+21.7 +21.8	Glasgow 1870.5853; Radcliffe 1890.6042
4	22 30 13.01	+4.14	. . . .	. .	Lalande 44136; Lamont 4602
5	22 35 28.18	+4.15 +4.17	− 4 5 24.0	+22.5 +22.6	Radcliffe 1890.6073
6	22 36 16.57	+4.15 +4.16	− 4 0 41.6	+22.5	Glasgow 1870.5912
7	22 25 5.66	+4.24	− 5 20 46.1	+22.4	Glasgow 1870.5846; Radcliffe 1890.6038
8	22 31 56.50	+4.28	− 6 35 59.6	+23.0	Lalande 44188; Lamont 4612
9	22 32 32.15	+4.28	− 6 36 27.7	+23.1	Lamont 4614
10	22 25 53.92	+4.32	− 7 4 47.4	+22.8	Schj. 9210; Greenwich 1880.3777; Radcliffe 1890.6041
11	22 21 10.02	+4.35 +4.35	− 7 51 1.4	+22.5 +22.6	Radcliffe 1890.6025
12	22 25 7.90	+4.37	− 8 38 32.9	+22.9	Radcliffe 1890.6039
13	22 21 21.69	+4.39	− 9 2 5.7	+22.7	Radcliffe 1890.6027
14	22 25 11.76	+4.45	−11 12 18.2	+22.9	Cape Catal. 1850.4505; Yarnall$_3$ 10161; Radcliffe 1860.2224; Brus. 1865.10065; Gr. 1872.2111; Arg. Gen. Catal. 30696; Gr. 1880.3769; Stone 11769; Melb. 1880.1098; Cape 1885.1598; Radcliffe 1890.6040
15	22 21 13.40	+4.46	−11 45 5.5	+22.5	Cape 1850.4494; Yarn. 10129; Gr. 1864.2564; Brus. 1865.10037; Arg. Gen. Catal. 30622; Rad. 1890.6026

These observations have been made with the 8-inch equatorial and filar micrometer in a bright field. The planet appears to have been much neglected of late years, and its orbit requires a considerable correction, as will be seen from the following results of a comparison by Mr. C. J. MERFIELD of Sydney, with the ephemeris in the *Berliner Astronomische Jahrbuch*. It is probable that Star No. 1 has a considerable proper motion in declination.

1897	Correction to Ephemeris in α	Correction to Ephemeris in δ	1897	Correction to Ephemeris in α	Correction to Ephemeris in δ
	m s	″		m s	″
Aug. 15	+1 14.06	+52.9	Aug. 26	+1 16.60	+49.2
15	+1 14.02	. .	26	+1 16.32	+48.1
16	+1 14.58	+44.0	29	+1 16.23	+45.8
17	+1 15.06	+43.3	30	+1 16.12	+44.9
17	+1 15.03	. .	31	+1 16.33	+43.1
18	+1 14.98	+46.6	Sept. 2	+1 16.15	+40.7
18	+1 14.79	+46.2	4	+1 16.03	+37.9
19	+1 15.27	+45.4	10	+1 14.79	+34.2
19	+1 15.12	. .	13	+1 14.06	+29.0
23	+1 15.91	+43.8			

Private Observatory, Windsor, N.S. Wales, 1897 *October* 6.

SMALL STARS NEAR *SIRIUS*,

BY E. E. BARNARD.

Dr. SEE has suggested, in his valuable paper on the companion of *Sirius*, *A.J.* 418, a method of determining the mass of *Sirius* by micrometrical measures of its position with reference to neighboring stars. He gives measures of four small stars near for this purpose.

In 1895 I measured *Sirius* with reference to two of these stars while examining it at the request of Mr. BURNHAM with the 36-inch.

A D	*D* = 14ᴹ±	
	°	″
1895.244	151.3	90.46
.266	151.6	90.57
1895.255	151.5	90.51

A C	*C* = 13ᴹ±	
1895.266	98.9	72.92

Dr. SEE's estimate of the magnitudes of these stars does not differ very much from mine, except that he reverses their order of brightness; *D* and *C* are his *E* and *D*.

With the 40-inch, here, I have measured two smaller stars nearer *Sirius*.

A and *E*	*E* = 16ᴹ	
1897.841	195°.4	57″.69

A and *F*	*F* = 16½ᴹ	
1897.841	3°.0	50″.08

There is another star of 15ᴹ, 50″± preceding *F*.

The motion of *Sirius* is nearly along the line of these two stars — towards *E* — at the rate of about 1⅓″ per year. It would therefore seem that *E* and *F* would be excellently suited for the investigation of the motion of *Sirius*, though a powerful telescope will be required for their measurement. The star *E* will become more difficult as *Sirius* approaches it, and before many years will become a close companion to the great star, at which time it will doubtless be beyond the reach of any telescope.

I did not notice any star in the position of Dr. SEE's *C* (190°.1 , 46″.16).

These objects will be measured again, and I simply send this note to call attention to the two smaller stars.

Yerkes Observatory, 1897 *Nov.* 19.

ELEMENTS OF COMET *b* 1897,

BY H. C. WILSON.

From the observation by PERRINE Oct. 16, and two by WILSON, Oct. 22 and 29, with the assistance of Miss A. S. YOUNG, I have computed the following elements of the comet's orbit:

$$T = \text{Dec. } 8.9216 \text{ Gr. M.T.}$$

$$\left.\begin{aligned} \omega &= 66^\circ\ 10'\ 11'' \\ \Omega &= 32\ \ \ 4\ \ \ 9 \\ i &= 69\ 37\ 21 \end{aligned}\right\} 1897.0$$

$$\log q = 0.131858$$

$$\Delta\lambda_{\prime\prime} \cos\beta_{\prime\prime} = -2'' \quad ; \quad \Delta\beta_{\prime\prime} = -2''$$

CONSTANTS FOR THE EQUATOR.

$$x = r\,[9.938187]\ \sin(168^\circ\ 28'\ 34'')$$
$$y = r\,[9.696962]\ \sin(168\ \ \ 2\ 31)$$
$$z = r\,[9.999996]\ \sin(\ 78\ 22\ \ \ 5)$$

With the 16-inch telescope the comet had at first very much the appearance of the WELLS's comet of 1882. It had until the last observation, on Nov. 1, a stellar nucleus of about 12ᴹ, a bright narrow streak of tail 4′ or 5′ long, and a broader exceedingly faint tail about 10′ long. The bright streak in the tail was so nearly equal in brightness to the very slight condensation about the nucleus that observers with small telescopes would be likely to bisect the streak rather than the nuclear condensation, and their observations might therefore be as much as 1′ or 2′ in error. Computers need therefore be on their guard to see that the observations which they use were made with sufficient light-gathering power to show the nucleus of the comet.

EPHEMERIS OF LONG-PERIOD VARIABLES FOR 1898,

BY S. C. CHANDLER.

The following ephemeris is based on the elements of the Third Catalogue, except for the stars indicated by an asterisk placed against the number. In these cases the following changes have been introduced.

		M—*m*	Maximum
103	*T* Andromedae	115	1891 Dec. 14 (241 2081) + 274 E
146	*T* Sculptoris	100 ::	1889 Nov. 29 (241 1336) + 203 E ?
267	*V* Andromedae	–	1896 Nov. 5 (241 3869) + 263 E
268	*X* Sculptoris	–	1895 Dec. 17 (241 3545) + 250 E ?
294	*W* Cassiopeae	215 :	1895 July 12 (241 3387) + 404 E ?
432	*S* Cassiopeae	300 :	1863 Apr. 19 (240 1615) + 609.5 E + 25 sin (18° E + 0°)
659	*X* Cassiopeae	230 :	1894 Sept. 10 (241 3082) + 380 E ?
2080	*R* Columbae		Elements of Third Catalogue rejected
2815	*U* Geminorum		Correction to Epoch of Third Catalogue $+20^d$
3244	*S* Pyxidis		1896 Mar. 3 (241 3622) + 213 E ?
4573	*RU* Virginis		1896 July 10 (241 3751) + 455 E
5190	*R* Camelop.		See *A.J.* XVII, p. 128
5249	*V* Librae		Elements of Third Catalogue rejected
6449	*T* Draconis		See *A.J.* XVII, p. 20

MAXIMA, 1898.

		M	Jan.
22	*V* Sculptoris	9	5
107	*T* Cassiopeae	7.5	15
268*	*X* Sculptoris	9	5 :
906	*R* Trianguli	6.5	21
1623	*T* Camelop.	7.5	21
2445	*W* Monocerotis	9	2 :
2735	*U* Canis min.	8.5	30
2742	*S* Geminorum	8.5	14
2815*	*U* Geminorum	9.3	2 :
3637	*S* Carinae	6	0
4225	*X* Centauri	8	0 :
4407	*R* Corvi	7	15
5070	*Z* Virginis	10	7
5566	*RU* Librae	8.5	30
6044	*S* Herculis	6.5	9 :
6849	*R* Aquilae	6.5	6
7192	*Z* Cygni	8	27
7266	*RT* Sagittarii	7.5	23
7299	*U* Cygni	7.5	29
7468	*T* Aquarii	7.5	24
7577	*X* Capricorni	10	22
7590	*Z* Capricorni	9	20 :
7999	*X* Aquarii	8.5	8
8622	*W* Ceti	8.5	10

		M	Feb.
401	*U* Sculptoris	8.5	19 :
434	*S* Piscium	8.5	10
976	*T* Arietis	8	5
1386	*T* Eridani	7	25
1582	*S* Tauri	9.5	28
1855	*R* Aurigae	7	27
1894	*T* Columbae	7.5	13
2258	*V* Aurigae	9	3
4511	*T* Ursae Maj.	7	7
5338	*U* Bootis	9.5	3
5494	*S* Librae	8	15
5593	*W* Librae	10	21
5776	*X* Scorpii	10	3
5903	*Y* Scorpii	10	9
5955	*R* Draconis	7.5	8
6132	*R* Ophiuchi	7.5	18
6207	*Z* Ophiuchi	8	9
7085	*RT* Cygni	7	15
7252	*W* Capricorni	10.5	10
7404	*R* Microscopii	8	22
7455	*U* Capricorni	10.5	15
7733	*Y* Capricorni	10.5	1
7909	*S* Piscis austr.	9	19

		M	Mar.
1850	*S* Pictoris	8.5	19 :
2100	*U* Orionis	7	28
2625	*V* Geminorum	8.5	29
2815	*U* Geminorum	9.3	29 :
2976	*V* Cancri	7	15
3264	*W* Cancri	9.5	12 :
4492	*Y* Virginis	8.5	1
4521	*R* Virginis	7	8
4596	*U* Virginis	8	21
5095	*R* Centauri	6	14
5237	*R* Bootis	7	13
5321	*S* Lupi	9.5	12 :
5504	*S* Coronae	7	8
6608	*RV* Sagittarii	8	26
6894	*S* Lyrae	9	31 :
6905	*R* Sagittarii	7.5	19
6943	*T* Sagittae	8.5	13 :
7139	*RR* Sagittarii	7.5	19
7220	*S* Cygni	10	19
7448	*W* Aquarii	8	5
7571	*V* Capricorni	9	17
7907	*U* Aquarii	9.5	12 :
8230	*S* Aquarii	8.5	31
8597	*V* Ceti	9	27

		M	Apr.
110	*S* Tucanae	8.5	29 :
146*	*T* Sculptoris	8	1 :
243	*U* Cassiopeae	8.5	13
267*	*V* Andromedae	8	15
845	*R* Ceti	8	4
1717	*V* Tauri	9	25
2583	L_2 Puppis	3.5	13
4557	*S* Ursae Maj.	7.5	3
5174	*RS* Virginis	8	10
5583	*X* Librae	9.5	1
5675	*V* Coronae	7.5	29
5795	*W* Scorpii	10.5	24
5830	*R* Scorpii	10	7
6062	*RR* Scorpii	7	14
6921	*S* Sagittarii	9.5	20
7120	χ Cygni	5	4
7444	*T* Delphini	9	7
7450	*V* Aquarii	8	20
7456	*RR* Cygni	8.5	16
8324	*V* Cassiopeae	7.5	19

		M	May
62	*S* Sculptoris	6.5	12 :
432*	*S* Cassiopeae	8	13
782	*R* Arietis	8	5
1805	*V* Orionis	8.5	28
1944	*S* Orionis	9	10
3060	*U* Cancri	9.5	22
3637	*S* Carinae	6	29
4260	*W* Centauri	8.5	31 :
4948	*R* Canum Ven.	6.5	26
5037	*RR* Virginis	11	17
5617	*U* Librae	9	1
5704	*RR* Librae	8.5	9
5831	*S* Scorpii	10	17
6682	*X* Ophiuchi	7	6
7118	*X* Aquilae	8.5	20
7242	*S* Aquilae	9	26
7260	*Z* Aquilae	9	7 :
7458	*Y* Delphini	9	12
7560	*R* Vulpeculae	8	15
7994	*R* Piscis austr.	8.5	20 :

		M	June
114	*S* Ceti	7.5	10
466	*U* Piscium	9.5	17
1222	*R* Persei	8.5	30
2528	*R* Geminorum	7	1
2691	*T* Canis min.	9.5	23
2815*	*U* Geminorum	9.3	23 :
2857	*U* Puppis	8.5	7
3184	*T* Hydrae	7.5	27
3994	*S* Leonis	9.5	7
4377	*T* Virginis	8.5	30
4826	*R* Hydrae	4.5	14
4847	*S* Virginis	6.5	17
5501	*S* Serpentis	8	11
5887	*V* Ophiuchi	7	1
5931	*S* Ophiuchi	8.5	17
6512	*T* Herculis	7.5	7
7261	*R* Delphini	8.5	25
7944	*T* Pegasi	9	19

		M	July
893	*U* Ceti	7	3
1981	*S* Camelop.	8.5	29
2266	*V* Monocerotis	6.5	26
3244*	*S* Pyxidis	8.5	3
4315	*R* Comae	7.5	19
4521	*R* Virginis	7	31
4816	*V* Virginis	8.5	13
5190*	*R* Camelop.	8	26
5338	*U* Bootis	9.5	30
5430	*T* Librae	9.5	8
5644	*Z* Librae	11	13
6449*	*T* Draconis	8	24 :

			July
		M	
6923	*Z* Sagittarii	8.5	10
7404	*R* Microscopii	8	11
7659	*T* Capricorni	9	21
7813	*R* Gruis	8.5	5
8040	*S* Gruis	7	19
8068	*S* Lacertae	8	22
		M	Aug.
112	*R* Andromedae	7	16
678	*U* Persei	7.5	31 :
715	*S* Arietis	9.5	8
1635	*R* Reticuli	7	5
2478	*R* Lyncis	8	20
2583	L_2 Puppis	3.5	31
2684	*S* Canis min.	7.5	22
2780	*T* Geminorum	8.5	18 :
3170	*S* Hydrae	8	20
3477	*R* Leonis min.	7	12
3493	*R* Leonis	6	17
4940	*W* Hydrae	6.5	15
5095	*R* Centauri	6	22
5157	*S* Bootis	8	21
5494	*S* Librae	8	27
5511	*RS* Librae	8	3
5770	*R* Herculis	8.5	24
5776	*X* Scorpii	10	21
6170	*RW* Scorpii	9.5	6 :
6943	*T* Sagittae	8.5	25 :
7077	*T* Pavonis	7.5	28
7085	*RT* Cygni	7	25
7428	*V* Cygni	8	12
7468	*T* Aquarii	7.5	16
7571	*V* Capricorni	9	21
7577	*X* Capricorni	10	25
7733	*Y* Capricorni	10.5	26
7779	*S* Cephei	8.5	7
		M	Sept.
103	*T* Androm.	8	14
268*	*X* Sculptoris	9	12 :

			Sept.
		M	
845	*R* Ceti	8	18
1582	*S* Tauri	9.5	4?
1894	*T* Columbae	7.5	19
2445	*W* Monocerotis	9	21 :
2530	*V* Canis min.	10	9
2815*	*U* Geminorum	9.3	18 :
3128	*R* Pyxidis	8	12 :
3418	*R* Carinae	5	13
3425	*X* Hydrae	8.5	15
3567	*V* Leonis	8.5	26
5194	*V* Bootis	7	6
5438	*Y* Librae	8.5	16 :
5583	*X* Librae	9.5	12
5593	*W* Librae	10	15
5677	*R* Serpentis	6.5	15
5761	*Z* Scorpii	9	9
5950	*W* Herculis	8	3
6050	*RS* Scorpii	7	7 :
6903	*T* Sagittarii	8	3
7234	*R* Capricorni	9.5	3 :
7252	*W* Capricorni	10.5	6
7260	*Z* Aquilae	9	14 :
7431	*S* Delphini	9	20
7455	*U* Capricorni	10.5	6
7456	*RR* Cygni	8.5	28
7482	*U* Pavonis	9.5	1
7560	*R* Vulpeculae	8	29
8153	*R* Lacertae	9	20
		M	Oct.
22	*Y* Sculptoris	9	27
806	*o* Ceti	3.5	6
906	*R* Trianguli	6.5	16
1018	*R* Horologii	6	21 :
1113	*U* Arietis	8	18
1577	*R* Tauri	8	24
1717	*V* Tauri	9	13
1771	*R* Leporis	6.5	21

			Oct.
		M	
1803	*T* Leporis	8	20 :
3637	*S* Carinae	6	24
3825	*R* Ursae Maj.	7	9
4492	*Y* Virginis	8.5	6
4511	*T* Ursae Maj.	7	20
4596	*U* Virginis	8	14
5237	*R* Bootis	7	24
5601	*S* Ursae min.	7.5	4
5856	*W* Ophiuchi	9	4
5928	*T* Ophiuchi	10	23 :
5955	*R* Draconis	7.5	12
6871	*V* Lyrae	9	22 :
7155	*RR* Aquilae	8.5	22 :
7192	*Z* Cygni	8	19
7242	*S* Aquilae	9	19
8290	*R* Pegasi	7.5	9
8373	*S* Pegasi	7.5	30
8512	*R* Aquarii	7	17
		M	Nov.
62	*S* Sculptoris	6.5	11
294*	*W* Cassiopeae	8.5	5 :
401	*U* Sculptoris	8.3	26 :
513	*R* Piscium	8	25
659*	*X* Cassiopeae	9.5	8 :
782	*R* Arietis	8	6
1386	*T* Eridani	7	5
2013	*U* Aurigae	8.5	5
2539	*R* Canis min.	7.5	16
2742	*S* Geminorum	8.5	4
4225	*X* Centauri	8	10 :
4407	*R* Corvi	7	29
4557	*S* Ursae Maj.	7.5	11
5070	*Z* Virginis	10	10
5830	*R* Scorpii	10	17
5831	*S* Scorpii	10	9
6044	*S* Herculis	6.5	13 :
6512	*T* Herculis	7.5	17

			Nov.
		M	
6624	*T* Serpentis	10	5
6849	*R* Aquilae	6.5	23
6900	*W* Aquilae	7.5	12 :
7266	*RT* Sagittarii	7.5	30
7404	*R* Microscopii	8	27
7907	*U* Aquarii	9.5	25 :
7909	*S* Piscis Austr.	9	18
7999	*X* Aquarii	8.5	15
		M	Dec.
267	*V* Andromedae	8	34
419	*U* Andromedae	9	25 :
466	*U* Piscium	9.5	7
976	*T* Arietis	8	15
1761	*R* Orionis	9	2
2258	*V* Aurigae	9	13
2625	*V* Geminorum	8.5	30
2815*	*U* Geminorum	9.3	13 :
2946	*R* Cancri	7	15
2976	*V* Cancri	7	12
4994	*S* Leonis	9.5	15
4521	*R* Virginis	7	23
4573*	*RU* Virginis	8	37 :
5037	*RR* Virginis	11	20
5566	*RU* Librae	8.5	16
5617	*U* Librae	9	13
5795	*W* Scorpii	10.5	2
5889	*U* Herculis	7	5
6132	*R* Ophiuchi	7.5	18
6331	*RU* Scorpii	9.5	15 :
6905	*R* Sagittarii	7.5	15
6921	*S* Sagittarii	9.5	7
7450	*V* Aquarii	8	16
7609	*T* Cephei	6	23
7783	*RU* Cygni	7.5	28
8230	*S* Aquarii	8.5	36
8324	*V* Cassiopeae	7.5	4
8597	*V* Ceti	9	13

MINIMA, 1898.

			Jan.
		M	
110	*S* Tucanae	<11	—
114	*S* Ceti	12	16
243	*U* Cassiopeae	<15	3
845	*R* Ceti	13	24
1805	*V* Orionis	<13	28 :
2528	*R* Geminor.	<13	31
2691	*T* Can. min.	<13	—
2857	*U* Puppis	<14	—
3060	*U* Cancri	<14	—
4847	*S* Virginis	12.5	11 :
5095	*R* Centauri	9	13 :
5583	*X* Librae	14	11
5617	*U* Librae	<14	—
6921	*S* Sagittarii	14.5	0 :
6943	*T* Sagittae	9.5	22 :
7261	*R* Delphini	12	26 :
7428	*V* Cygni	13.5	4
7456	*RR* Cygni	9.5	—
7813	*R* Gruis	<12	—
7944	*T* Pegasi	<13	—

			Jan.
		M	
7994	*R* Pisc. Aust.	<11	—
8324	*V* Cassiopeae	12	4 :
		M	Feb.
62	*S* Sculptoris	10	—
112	*R* Androm.	<13	27 :
715	*S* Arietis	14	24 :
782	*R* Arietis	12	2
1717	*V* Tauri	<13	2
1981	*S* Camelop.	11	10
2266	*V* Monocer.	11	—
2583	L_2 Puppis	6	3
3184	*T* Hydrae	<13	—
3477	*R* Leo. min.	13	23
3994	*S* Leonis	<13	2 :
4315	*R* Comae	<13	—
4377	*T* Virginis	12	—
4940	*W* Hydrae	8	—
5037	*RR* Virginis	<14	—
5644	*Z* Librae	<13	—

			Feb.
		M	
5831	*S* Scorpii	<13	—
5931	*S* Ophiuchi	<13	—
6170	*RW* Scorpii	14	—
7659	*T* Capricorni	13.5	22
		M	Mar.
466	*U* Piscium	15	26
659*	*X* Cassiopeae	12	23 :
678	*U* Piscium	11.5	16 :
893	*U* Ceti	12	3 :
1222	*R* Persei	13	26
1771	*R* Leporis	8.5	23
2478	*R* Lyncis	<13	30
2530	*V* Can. min.	<13	—
2684	*S* Can. min.	11	11
3244*	*S* Pyxidis	11	—
3493	*R* Leonis	10	26
3637	*S* Carinae	9	4
4816	*V* Virginis	<13	—
5190*	*R* Camelop.	12.5	28 :

			Mar.
		M	
5430	*T* Librae	<14	25
5761	*Z* Scorpii	12	—
5770	*R* Herculis	<13	—
6512	*T* Herculis	11	21
6900	*W* Aquilae	11	—
6903	*T* Sagittarii	<11	—
7242	*S* Aquilae	11	15
7260	*Z* Aquilae	11	—
7560	*R* Vulpeculae	13	14
8068	*S* Lacertae	<12	31
		M	Apr.
294*	*W* Cassiopeae	11.5	4 :
1635	*R* Reticuli	<13	—
2013	*U* Aurigae	12	—
2780	*T* Geminor.	<13	—
3128	*R* Pyxidis	<11	—
3170	*S* Hydrae	<12	—
3418	*R* Carinae	9.5	30
5157	*S* Bootis	12.5	17

		M	Apr.
5338	*U* Bootis	12.5	26
5511	*RS* Librae	13	—
5677	*R* Serpentis	13	17
6050	*RS* Scorpii	11.5	—
7155	*RR* Aquilae	<12	—
7234	*R* Capric.	<13	—
7182	*U* Pavonis	<12	—
7577	*X* Capric.	<16	30:
8290	*R* Pegasi	<13	20:
8512	*R* Aquarii	11	—
		M	May
103	*T* Androm.	13	22
268*	*X* Sculptoris	12	—
1018	*R* Horologii	10	—
1113	*U* Arietis	<11	—
1761	*R* Orionis	12	2:
1803	*T* Leporis	11	—
2445	*W* Monocer.	<10	—
3425	*X* Hydrae	12	—
3567	*V* Leonis	<13	—
4521	*R* Virginis	10.5	23
4573*	*RU* Virginis	12	—
5438	*Y* Librae	12	—
5491	*S* Librae	<13	—
5601	*S* Ursae min.	11.5	—
5776	*X* Scorpii	<13	—
5856	*W* Ophiuchi	<13	—
5950	*W* Herculis	13	1
6871	*V* Lyrae	<12	—
7077	*T* Pavonis	12	—
7085	*RT* Cygni	10.5	29
7404	*R* Microscop.	12	8
7431	*S* Delphini	11	25
7455	*U* Capric.	<13	—
7468	*T* Aquarii	12.5	20
7733	*Y* Capricorni	14	—
8153	*R* Lacertae	<13	—
		M	June
22	*V* Sculpt.	<12	—
513	*R* Piscium	<13	29
806	*O* Ceti	9	16
906	*R* Trianguli	11.5	19
1577	*R* Tauri	13	6:
1582	*S* Tauri	13	26?
1894	*T* Columbae	11	—
2583	L_2 Puppis	6	23
2742	*S* Geminor.	<13	30:
3825	*R* Ursae Maj.	12.5	24
4225	*X* Centauri	12	23:
5070	*Z* Virginis	<14	—
5095	*R* Centauri	9	23:
		M	June
5194	*V* Bootis	9.5	1
5583	*X* Librae	14	24
5593	*W* Librae	<14	—
5889	*U* Herculis	12	21
5955	*R* Draconis	12.5	22
6044	*S* Herculis	12	18:
6331	*RU* Scorpii	12.5	—
6624	*T* Serpentis	<13	—
7192	*Z* Cygni	11.5	16:
7252	*W* Capric.	<14	11:
7571	*V* Capricorni	14	—
7609	*T* Cephei	9.5	6
7783	*RU* Cygni	9	—
7999	*X* Aquarii	13	—
8373	*S* Pegasi	13	9:
		M	July
146*	*T* Sculptoris	10	13:
404	*U* Sculpt.	<12	—
449	*U* Androm.	<13	—
845	*R* Ceti	13	10
1386	*T* Eridani	11	—
1717	*V* Tauri	<13	23
2539	*R* Can. min.	10	9:
3637	*S* Carinae	9	30
4407	*R* Corvi	<11	—
4492	*Y* Virginis	12	13:
4511	*T* Ursae Maj.	12.5	4
4557	*S* Ursae Maj.	11	21
4596	*U* Virginis	12.5	18
5237	*R* Bootis	12	14
5566	*RU* Librae	<12	—
5795	*W* Scorpii	<14	9
5830	*R* Scorpii	<13	—
6132	*R* Ophiuchi	<12	—
6849	*R* Aquilae	11	2
6905	*R* Sagittarii	12.5	23
6943	*T* Sagittae	9.5	6:
7260	*Z* Aquilae	11	—
7266	*RT* Sagittarii	<11	—
7456	*RR* Cygni	9.5	—
7560	*R* Vulpeculae	13	29
7907	*U* Aquarii	14	—
7909	*S* Pisc. aust.	<11	—
		M	Aug.
62	*S* Sculptoris	10	—
107	*T* Cassiopeae	11.5	8
267*	*V* Androm.	<12	—
782	*R* Arietis	12	7
976	*T* Arietis	9.5	10
1623	*T* Camelop.	<12	4:
2258	*V* Aurigae	<11	13:
		M	Aug.
2625	*V* Geminor.	13	20
2946	*R* Cancri	<11	12:
2976	*V* Cancri	<12	24
3994	*S* Leonis	<13	12:
5617	*U* Librae	<14	—
5831	*S* Scorpii	<13	—
5903	*Y* Scorpii	14	—
6207	*Z* Ophiuchi	12	11:
6512	*T* Herculis	11	31
6921	*S* Sagittarii	11.5	19:
7242	*S* Aquilae	11	8
7450	*V* Aquarii	9.5	—
7590	*Z* Capricorni	11.5	—
8230	*S* Aquarii	<12	—
8324	*V* Cassiopeae	12	21:
8597	*V* Ceti	14	—
8600	*R* Cassiopeae	10	22
8622	*W* Ceti	12	—
		M	Sept.
110	*S* Tucanae	<11	—
434	*S* Piscium	<14	2
466	*U* Piscium	15	15
1855	*R* Aurigae	12.5	27
2735	*U* Can. min.	12.5	22
3264	*W* Cancri	<13	—
5037	*RR* Virginis	<14	—
5321	*S* Lupi	<12	—
6062	*RR* Scorpii	9.5	18:
6608	*RV* Sagittarii	12	—
7045	*R* Cygni	<14	2
7220	*S* Cygni	<14	5
7299	*U* Cygni	10.5	28
7404	*R* Micros.	12	24
7448	*W* Aquarii	9.5	22:
		M	Oct.
243	*U* Cassiop.	<15	6
893	*U* Ceti	12	25:
1222	*R* Persei	13	22
1805	*V* Orionis	<13	21:
1850	*S* Pictoris	<13	—
3244*	*S* Pyxidis	11	—
4521	*R* Virginis	10.5	15
5174	*RS* Virginis	12	—
5338	*U* Bootis	12.5	19
5675	*V* Coronae	11	31
5704	*RR* Librae	14	—
5887	*V* Ophiuchi	10	6:
5931	*S* Ophiuchi	<13	—
7139	*RR* Sagittarii	<12.5	3:
7444	*T* Delphini	<13	—
7994	*R* Pisc.austr.	<11	—
		M	Nov.
2100	*U* Orionis	<12	13:
2583	L_2 Puppis	6	10
2857	*U* Puppis	<14	—
3060	*U* Cancri	<14	—
3184	*T* Hydrae	<13	—
4846	*V* Virginis	<13	—
4948	*R* Can. Ven.	11.5	—
5095	*R* Centauri	9	30
5430	*T* Librae	<13	18
5504	*S* Coronae	12	8
5511	*RS* Librae	13	—
5776	*X* Scorpii	<13	—
6682	*X* Ophiuchi	9	—
6894	*S* Lyrae	12	—
7118	*X* Aquilae	<12	—
7120	χ Cygni	13.5	25
7260	*Z* Aquilae	11	—
7261	*R* Delphini	12	7:
7577	*X* Capric.	<16	—
7571	*V* Capricorni	14	—
7659	*T* Capricorni	13.5	18
8068	*S* Lacertae	<12	19
		M	Dec.
114	*S* Ceti	12	2
715	*S* Arietis	14	13:
1582	*S* Tauri	13	30
1635	*R* Reticuli	<13	—
1717	*V* Tauri	<13	40
1894	*T* Columbae	11	—
1944	*S* Orionis	12	15
1981	*S* Camelop.	11	20
2691	*T* Can. min.	<13	—
3170	*S* Hydrae	<12	—
3186	*T* Cancri	10	24
4260	*W* Centauri	13	—
4377	*T* Virginis	12	—
5157	*S* Bootis	12.5	30
5190*	*R* Camelop.	12.5	27:
5494	*S* Librae	<13	—
5501	*S* Serpentis	12.5	—
5583	*X* Librae	14	5
5593	*W* Librae	<14	—
5644	*Z* Librae	<13	—
6943	*T* Sagittae	9.5	18:
7077	*T* Pavonis	12	—
7085	*RT* Cygni	10.5	7
7242	*S* Aquilae	11	33
7252	*W* Capric.	<14	36:
7455	*U* Capric.	<13	—
7456	*RR* Cygni	9.5	—
7468	*T* Aquarii	12.5	10
7733	*Y* Capricorni	14	—

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RESULTS OF LATITUDE-OBSERVATIONS AT THE IMPERIAL OBSERVATORY OF KASAN,

Communicated by D. DUBIAGO.

Daily Means.

(1) Definitive Reduction.

Date	φ	Pairs
1895 Feb. 8	55° 47′ 22″.96	5
11	23.06	4
18	23.09	11
19	23.05	14
27	22.88	16
Mar. 1	22.99	13
3	23.04	16
7	23.02	5
8	22.91	8
13	23.05	8
14	23.01	15
15	23.17	15
16	23.35	15
20	23.06	15
26	23.04	15
27	23.13	4
31	23.27	15
Apr. 1	23.24	14
11	22.98	14
18	23.02	16
19	23.02	16
20	23.00	16
21	23.18	16
22	23.15	16
24	23.01	16
25	23.01	12
26	23.07	16
27	23.10	8
May 3	23.20	16
5	23.28	15
7	23.05	15
8	23.13	15
10	22.99	14
15	23.30	15
16	23.13	4
19	23.31	15
20	23.33	15
23	23.16	15
24	55 47 23.23	15
1895 June 11	55° 47′ 23″.20	14
12	23.10	14
14	23.16	14
15	23.08	14
16	23.22	13
19	23.26	14
20	23.20	14
22	23.08	14
25	23.22	14
26	23.22	14
July 22	23.28	14
23	23.08	14
28	23.43	1
30	23 24	22
31	23.20	14
Aug. 23	23.27	10
25	23.23	15
31	23.17	14
Sept. 1	23.15	4
4	23.39	7
5	23.32	13
11	23.09	15
15	23.07	15
16	23.17	15
17	23.09	15
Oct. 4	23.30	17
10	23.32	16
11	23.19	5
12	23.15	7
13	23.13	17
22	23.11	17
25	23.14	17
26	23.18	17
Nov. 3	23.13	8
11	23.22	17
12	23.09	17
13	23.09	17
24	23.05	13
28	55 47 23.08	8
1895 Dec. 13	55° 47′ 23″.07	14
14	23.23	17
15	23.04	4
25	22.86	3
28	22.85	4
31	22.99	9
1896 Jan. 1	22.90	12
7	22.88	17
10	22.87	14
16	22.97	13
22	22.72	9
24	22.93	25
25	23.14	3
26	23.03	4
28	22.94	1
Feb. 1	23.05	8
2	23.10	16
9	23.00	4
13	22.89	16
15	22.74	16
18	22.88	8
19	23.09	16
22	22.90	16
26	23.05	14
Mar. 8	23.16	15
11	22.92	15
20	22.82	15
25	22.92	15
30	22.89	15
31	22.60	3
Apr. 5	23.15	15
9	23.05	15
10	22.96	16
14	22.93	16
17	22.86	11
18	22.86	16
20	22.92	8
23	22.94	16
28	55 47 22.94	16
1896 May 2	55° 47′ 23″.06	16
7	22.96	15
17	23.00	15
23	23.00	15
June 2	22.95	11
3	22.98	14
4	22.96	16
8	22.94	14
15	22.95	3
16	23.01	14
19	23.04	14
21	23.00	6
22	22.98	14
23	22.78	12
24	22.98	14
28	23.13	13
July 14	23.20	14
15	23.24	13
24	23.24	14
25	23.24	14
27	23.20	14
28	23.27	14
30	23.10	10
Aug. 4	23.13	14
15	23.08	11
23	23.35	15
26	23.30	15
Sept. 9	23.27	6
12	23.48	14
13	23.36	15
20	23.42	11
22	23.27	15
23	23.19	15
26	23.23	15
27	23.30	15
Oct. 2	23.24	11
3	23.21	8
5	55 47 23.17	3

Date	φ	Pairs
1896	° ′ ″	
Oct. 7	55 47 23.43	12
10	23.29	17
11	23.24	17
13	23.23	17
22	23.27	8
28	23.19	17
Nov. 21	23.46	1
22	23.39	5
23	23.23	17
Dec. 1	23.23	5
2	23.32	16
3	23.50	7
8	23.35	17
9	23.13	8
16	23.35	9
21	23.37	9
24	23.10	9
26	23.15	13
1897		
Jan. 20	23.19	3
21	22.93	8
22	22.92	16
24	22.92	3
26	22.98	5
31	55 47 22.84	9
1897	° ′ ″	
Feb. 2	55 47 22.80	2
5	22.94	15
6	22.82	17
8	22.93	6
9	22.94	5
11	23.05	18
15	23.07	3
17	22.95	19
18	22.50	2
Mar. 10	23.00	16
11	23.19	15
12	22.93	8
13	23.18	14
14	23.22	14
15	22.84	14
16	22.77	14
22	22.95	15
23	22.76	14
24	23.31	15
31	22.82	15
Apr. 4	22.90	15
5	22.77	15
8	22.86	15
9	22.84	15
10	55 47 22.88	16
1897	° ′ ″	
Apr. 12	55 47 22.98	16
28	22.77	16
29	22.77	16
30	22.82	4
May 2	22.69	6
4	22.97	15
6	22.96	6
11	23.06	8
13	22.84	3
16	22.94	15
20	22.96	11
25	22.71	9
27	23.01	15
28	22.74	14
31	22.82	14
June 1	22.84	14
2	22.96	14
3	22.87	14
4	22.75	14
8	22.91	13
10	22.77	14
11	22.76	14
18	55 47 23.04	14
(2) Provisional Reduction.		
1897	° ′ ″	
July 3	55 47 22.90	14
14	23.00	4
15	23.00	14
16	22.99	14
17	23.08	14
22	23.07	14
23	23.05	14
26	23.00	14
27	23.14	14
Aug. 10	23.00	15
11	23.11	15
16	23.22	15
17	23.28	15
20	23.03	15
21	23.05	11
23	23.22	5
24	23.20	14
Sept. 10	23.21	15
12	23.12	12
22	23.24	17
27	23.31	17
28	23.15	1
29	55 47 23.07	3

MONTHLY MEANS.

Date	φ	Pairs
(1) Definitive.		
1895	° ′ ″	
Feb. 20	55 47 23.00	50
Mar. 15	23.10	144
Apr. 19	23.07	160
May 13	23.20	154
June 18	23.17	139
July 17	23.21	65
Aug. 27	23.22	39
Sept. 12	55 47 23.16	84
1895	° ′ ″	
Oct. 16	55 47 23.19	113
Nov. 15	23.11	80
Dec. 19	23.08	51
1896		
Jan. 15	22.91	98
Feb. 15	22.96	114
Mar. 19	22.93	78
Apr. 16	22.96	129
May 12	55 47 23.01	61
1896	° ′ ″	
June 15	55 47 22.98	145
July 23	23.22	93
Aug. 17	23.23	55
Sept. 20	23.31	106
Oct. 12	23.26	110
Nov. 23	23.27	23
Dec. 12	23.28	93
1897		
Jan. 24	55 47 22.93	44
1897	° ′ ″	
Feb. 10	55 47 22.93	87
Mar. 18	23.00	154
Apr. 14	22.85	128
May 19	22.89	116
June 7	22.86	111
(2) Provisional.		
July 20	23.03	116
Aug. 17	23.13	105
Sept. 19	55 47 23.22	65

THE ABERRATION OF PARABOLIC MIRRORS,*

BY CHARLES LANE POOR.

The form of mirror discussed in this article was first suggested by Professor PICKERING. The beauty and simplicity of the resulting equatorial mounting led me to an attempt to grind and polish a small mirror of this kind; these attempts were partially successful. I did not, however, obtain anything like the definition I had hoped for. At the time I attributed this to bad figuring and inexperienced workmanship, and thought that with due care a perfect mirror could ultimately be constructed. A thorough investigation of the optical theory of the surface now convinces me that a great part of the trouble was inherent in the form itself, and that however perfect the figure of the mirror might be, the definition would be so poor, except in the center of the field, as to render the mirror useless for all astronomical purposes.

The mirror in question is a portion of the surface of a paraboloid of revolution, cut at the extremity of the *latus rectum*, and has the property of bringing to a single focus all the rays parallel to the axis of figure, the axis of the reflected pencil being perpendicular to that of the incident beam.

The experiments above referred to were described at the Astronomical Conferences held in connection with the dedication of the Yerkes Observatory. An abstract of that paper describing the form of mounting has appeared in the *Astrophysical Journal*.

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* The formulas and conclusions of this article were derived during the first week in November. The manuscript was mailed Nov. 23, the day on which No. 419, containing Prof. SCHAEBERLE'S article, went to press. His article reached me on Dec. 1. — C. L. P.

For this form of mirror the center of the field is perfect. To investigate the field as a whole, take the center of mirror as origin of coordinates, and the central reflected ray as the axis of X. Call f the focal length of the mirror; θ, the angular aperture of the mirror as viewed from the principal focus. Consider now a beam of parallel light incident on the surface of the mirror at an angle α to the axis of figure or $90^\circ+\alpha$ to the axis of X. As in the last case a ray incident at the center of the mirror will be reflected at an angle α with the axis of X. A ray from the edge of the mirror intersects this central ray at a distance f' from the origin. A rigorous expression for f' in terms of f, θ and α can be derived in a manner similar to that of the former case discussed, and is found to be

$$(1)\qquad f' = \frac{f}{1-\sin\theta}\left[\cos(\alpha+\theta)+\sin(\alpha+\theta)(\tan\tfrac{1}{2}\theta-1)\right]$$

This is a general formula for this case; by making θ vary between its extreme positive and negative values we find the focal length of different portions of the mirror; by making α vary we find the focal lengths for different portions of the field. Put $\alpha =$ to zero and we find $f'=f$, which shows that rays parallel to the axis of figure from all portions of the mirror are brought to a single focus; this is the ordinary principle of a paraboloid of revolution.

Put θ equal to zero and our general equation reduces to

$$(2)\qquad f_0' = f(\cos\alpha-\sin\alpha)$$

and this is the equation of the field for the parabolic section of the mirror under consideration. It is a circle of radius $\frac{f}{\sqrt{2}}$ and whose center is situated at a point whose coordinates are $+\frac{1}{2}f$ and $-\frac{1}{2}f$. The field of this parabolic section is therefore inclined at an angle of 45° to the central ray, or to the axis of X. It is, however, flatter than the field of the usual form of mirror; the radii of the circles for mirrors of the same focal length being in the ratios of 1 to the $\sqrt{2}$. It might be possible to use a photographic plate with a section of a mirror of the above form, but it would be next to impossible to use an eyepiece, as the axis of the eyepiece must be placed parallel to the axis of the pencil of light falling upon it, and as the field is inclined to this, the eyepiece would have to be focussed for each and every portion of the field; only one point of the field being in focus at any one time.

The linear aberration along the central ray for the beam of light incident at the angle α is given by,

$$\Delta f' = f'-f_0'$$

and substituting the values of f' and f_0' in this we find after some trigonometrical reductions,

$$\Delta f' = -f\sin\alpha\left[\tan\tfrac{1}{2}\theta+\tan\theta\tan(45^\circ+\tfrac{1}{2}\theta)\right]\qquad(3)$$

which is a rigorous expression for the aberration. Comparing this expression with the corresponding expression for the aberration of an ordinary mirror we find that they differ only in the last term of the parenthesis. For all possible values of θ, this term in the above equation is always greater than the corresponding term in the expression for the common form of mirror. Hence in the form now discussed the aberration is always greater than in the older form of mirror.

Again, calling γ the injurious effect of the aberration (γ being the angle that the transverse linear aberration subtends at the center of the mirror) we have as in the former paper,

$$\gamma = \frac{\tan\theta}{(1-\cot\alpha)\tan 1''}\left[\tan\tfrac{1}{2}\theta+\tan\theta\tan(45^\circ+\tfrac{1}{2}\theta\right]\qquad(4)$$

and this is an expression for the size of the star disc in the field of least aberration.

In the former case the reduction for curvature of the field was very small in comparison with the aberration; in the present case, the reduction for curvature and inclination of the field is very large in comparison to the aberration, unless the field is taken at an angle to the incident light.

To sum up my investigation in regard to this form of mirror we have:

Points in favor: 1. Convenience and rigidity of equatorial mounting. 2. Freedom from diffraction caused by the secondary mirror.

Points against: 1. Difficulty of making; hence increased cost. This is offset by the saving in the cost of mounting. 2. Inclination of the field. 3. Great aberration; hence the useful field is much smaller than that of the ordinary form.

Taking all these points into consideration, I am forced to the conclusion that this form is useless for practical work. This is extremely disappointing, for at first sight the advantages of this form seemed to far outweigh any increased cost owing to the difficulty of grinding and polishing.

NOTES ON VARIABLE STARS, — No. 21,

By HENRY M. PARKHURST.

V Lyrae. The depression of $0^{\mathrm{M}}.3$ observed last year, producing two equal maxima (*Astronomical Journal* 393), was not repeated. Revising the observations of last year, using the latest determinations for the factors and for the comparison-stars, the depression remains; but the second becomes the principal maximum, the time being unchanged.

Correction. In *A.J.* 415, *R Hydrae*, April 12, for $5^{\mathrm{M}}.59$ read $4^{\mathrm{M}}.59$. On April 15, the discrepancy of a magnitude is neither typographical nor clerical.

RESULTS OF OBSERVATIONS.

No.	Star	Phase	Observed Date		E	Corr.	W	Mag.	Factors			Remarks
			Julian	Calendar								
				1897								
5593	*W Librae*	Max.	4101	June 25	34	−35	9	11.70	0.41	0.37	7^{d}	
5675	*V Coronae*	Max.	4050	May 5	19	−2	8	9.1	–	–	–	Minor max. 3 weeks later
5688	*R Librae*	Max.	4097	June 21	–	–	3	11.4	–	0.80	–	Probably a few days earlier $nP = 715$: days
5704	*RR Librae*	Max.	4130	July 24	16	−12	6	8.91	–	–	–	
5770	*R Herculis*	Max.	4191	Sept. 23	37	−15	9	9.32	1.28	1.64	25	
5776	*X Scorpii*	Max.	4126	July 20	39	+1	9	11.25	0.82	0.89	29	
5795	*W Scorpii*	Max.	4157	Aug. 20	35	−24	3	–	–	–	–	Corresponds with 388
5830	*R Scorpii*	Min.	4050	May 5	56	–	E	–	–	–	–	
5831	*S Scorpii*	Max.	4086	June 10	124	+13	3	10.9	–	–	–	Very uncertain
5887	*V Ophiuchi*	Max.	4093	June 17	28	−47	9	7.48	1.05	1.05	23	Fluctuation; only one max.
5950	*W Herculis*	Min.	4112	July 6	24	−11	2	–	–	–	–	Observations unsatisfactory
6014	*S Herculis*	Min.	4183	Sept. 15	49	+32	8	12.94	1.31	1.00	70	+10, by transition el. 388
6160	*RT Herculis*	Max.	4107	July 1	–	–	9	10.02	1.04	0.26	12	Period 310 days?
6207	*Z Ophiuchi*	Min.	4156	Aug. 19	5	−9	8	12.55	0.79	0.98	25	
6512	*T Herculis*	Max.	4123	July 17	65	+3	7P	7.6	0.57	0.46	35	
..	..	Min.	4211	Oct. 13	66	+5	9	13.15	0.83	0.82	43	
6682	*X Ophiuchi*	Max.	4089	June 13	12	+8	9	6.86	0.58	1.33	18	Fluctuation
6849	*R Aquilae*	Min.	4189	Sept. 21	45	+37	9	13.14	2.27	1.69	42	−8, by sine el. 365
6871	*V Lyrae*	Max.	4222	Oct. 24	4	+14	9	10.68	1.30	0.90	21	See note above
6888	*RW Sagittarii*	Max.	4184	Sept. 16	–	–	9	9.32	0.26	0.48	11	Great fluctuation
6892	*RX Sagittarii*	Max.	4098	June 22	–	–	3	8.5	–	0.6	30	Period 320 days?
6894	*S Lyrae*	Max.	3950	Jan. 25	3	–	E	–	–	–	–	Obsns. tend to confirm period
6900	*W Aquilae*	Max.	4090	June 14	2	−1	7	9.18	0.96	2.16	35	Fluctuating; comp. with el. 393

INDIVIDUAL OBSERVATIONS.

Including Observations by ARTHUR C PERRY.

5593 *W Librae.*

(Continued from 388.)

Julian	Calendar	Mag.
	1897	
4064.7	May 19	11.6]
4074.7	29	13.1]
4094.6	June 18	11.7
4096.6	20	11.53_2
4096.6	20	11.5:P
4097.6	21	11.68_2
4098.6	22	11.91_2
4099.6	23	11.70_2
4101.6	25	11.59_2
4102.6	26	11.8P
4103.6	27	11.77_2
4106.6	30	11.87_2
4110.6	July 4	12.01_2
4128.6	22	12.29_2
4136 6	30	12.5]

5675 *V Coronae.*

(Continued from 388.)

Julian	Calendar	Mag.
	1897	
4018.6	Apr. 3	9.5
4027.6	12	9.3
4035.5	20	9.49_2
4044.6	29	8.96_2
4052.6	May 7	9.06_2
4060.6	15	9.36
4063.6	18	9.35_2
4076.6	31	9.07_2
4077.6	June 1	9.35_2
4087.6	11	9.23_2
4088.6	12	9.21

5688 *R Librae.*

(Continued from 365.)

Julian	Calendar	Mag.
	1896	
3684.6	May 4	to
3774.6	Aug. 2	12.0]
	8 dates	
	1897	
4064.7	May 19	12.0]
4097.6	June 21	11.41_2
4098.6	22	11.71_2
4099.6	23	11.56_2
4101.6	25	11.78_2
4103.6	27	11.70_2
4106.6	30	11.55_2
4110.6	July 4	11.81_2
4113.6	7	11.57_2
4128.6	22	12.31

5704 *RR Librae.*

(Continued from 333.)

Julian	Calendar	Mag.
	1897	
4121.5	July 15	8.98_2
4131.6	25	8.94_2
4137.6	31	8.94_2
4143.6	Aug. 6	9.26_2

5770 *R Herculis.*

Julian	Calendar	Mag.
	1897	
4018.6	Apr. 3	to
4140.6	Aug. 3	12.9]
	11 dates	
4157.6	Aug. 20	10.6
4166.5	29	10.11_2
4173.5	Sept. 5	9.52_2
4182.5	Sept. 14	9.56_2
4189.5	21	9.33_2
4194.5	26	9.39_2
4199.5	Oct. 1	9.41_2
4206.5	8	9.40_2
4211.5	13	9.62_2

5776 *X Scorpii.*

Julian	Calendar	Mag.
	1897	
4074.7	May 29	13.0:
4097.7	June 21	12.2
4098.6	22	12.24_2
4099.6	23	12.15_2
4101.6	25	12.05_2
4103.6	27	12.18_2
4106.6	30	11.86_2
4110.6	July 4	11.48_2
4113.6	7	11.67_2
4128.6	22	11.32_2
4136.6	30	11.39_2
4140.6	Aug. 3	11.57_2
4142.6	5	11.74_2

5795 *W Scorpii.*

(Continued from 388.)

Julian	Calendar	Mag.
	1897	
4121.5	July 15	11.1]
4125.5	19	12.0]
4136.6	30	12.0:
4140.6	Aug. 3	12.3
4157.6	20	11.4
4163.6	26	11.5

5830 *R Scorpii.*

(Continued from 333.)

Julian	Calendar	Mag.
	1897	
4074.7	May 29	to
4094.6	June 18	13]
	4 dates	

5831 *S Scorpii.*

(Continued from 365.)

Julian	Calendar	Mag.
	1897	
4074.7	May 29	12.2
4077.7	June 1	11.5
4078.6	2	10.94_2
4094.6	18	11.6

5887 *V Ophiuchi.*

(Continued from 365.)

Julian	Calendar	Mag.
	1897	
4074.6	May 29	7.58_2
4078.6	June 2	7.58_2
4087.6	11	7.83_2
4090.6	14	7.26_2
4091.6	15	7.52_2
4101.6	25	7.95_2
4111.6	July 5	7.49_2
4113.6	7	8.02_2
4114.6	8	7.57_2
4121.6	15	8.06_2
4128.6	22	7.9P
4136.6	30	8.4P
4137.6	31	8.48_2
4140.6	Aug. 3	8.3P
4142.6	5	8.0P
4148.6	11	8.04_2
4157.5	Aug. 20	8.5P
4159.5	22	8.34_2
4163.6	26	8.6P
4168.5	31	8.22_2
4168.6	31	8.7P
4173.5	Sept. 5	8.33_2
4183.5	15	8.33_2

5950 *W Herculis.*

(Continued from 365.)

Julian	Calendar	Mag.
	1897	
4074.6	May 29	13.3
4098.6	June 22	13.1
4111.6	July 5	13.3]
4121.6	15	12.4]
4125.6	19	12.4]
4136.6	30	12.7:
4140.6	Aug. 3	13.1
4157.6	20	13.0
4163.6	26	11.9

6044 *S Herculis.*

Cont. from 388. Comp. Stars 388)

Julian	Calendar	Mag.
	1897	
4078.7	June 2	9.8
4097.7	21	10.9
4108.6	July 2	11.0
4128.6	22	12.3
4136.6	30	11.71_2
4138.6	Aug. 1	11.62_2
4142.6	5	11.97_2

6044 *S Herculis*—Cont.

Julian	Calendar	Mag.
	1897	
4159.6	Aug. 22	12.5]
4163.6	26	12.8
4165.6	28	12.64_2
4185.5	Sept. 17	12.7
4195.5	27	12.3]
4211.5	Oct. 13	12.3
4212.5	14	12.10_2

6160 *RT Herculis.*

Julian	Calendar	Mag.
	1896	
3862.5	Oct. 29	11.2
3897.5	Dec. 3	11.5]
	1897	
4044.6	Apr. 29	12]
4052.6	May 7	12]
4074.6	29	11.0
4077.6	June 1	10.69_2
4094.7	18	10.5
4098.6	22	10.33_2
4102.6	26	9.98_2
4107.6	July 1	10.14_2
4108.6	2	9.91_2
4109.6	3	10.08_2
4110.6	4	10.24_2
4114.6	8	10.38_2
4140.6	Aug. 3	10.63_2
4151.6	14	10.64_2
4163.6	26	10.99_2

6207 *Z Ophiuchi.*

(Cont.from 388. Comp.Stars 333)

Julian	Calendar	Mag.
	1897	
4078.7	June 2	10.9
4098.6	22	10.9
4111.6	July 5	11.8
4128.6	22	11.7
4137.6	31	12.16_2
4142.6	Aug. 5	12.10_2
4159.6	22	11.8]
4163.6	26	12.51_2
4166.6	29	12.33_2

6207 *Z Ophiuchi*—Cont.

Julian	Calendar	Mag.
	1897	
4168.6	Aug. 31	12.37_2
4183.5	Sept. 15	12.28_2
4192.5	24	12.51_2
4194.5	26	12.20
4195.5	27	12.39_2
4212.5	Oct. 14	11.80_2

6512 *T Herculis.*

(Continued from 388.)

Julian	Calendar	Mag.
	1897	
4076.6	May 31	11.5P
4094.7	June 18	10.6P
4097.6	21	9.6P
4102.6	26	9.1P
4115.6	July 9	7.3P
4121.6	15	7.9P
4128.7	22	7.7P
4140.6	Aug. 3	8.8P
4185.5	Sept. 17	12.29_2
4189.5	21	12.40_2
4193.5	25	12.53_2
4197.5	29	13.19_2
4213.5	Oct. 15	12.98_2
4224.5	26	12.79_2
4242.5	Nov. 13	12.1;
4247.5	18	11.39_2
4250.5	21	10.96_3

6682 *X Ophiuchi.*

(Continued from 388.)

Julian	Calendar	Mag.
	1897	
4053.7	May 8	7.1
4064.6	19	7.0P
4074.6	29	7.3
4076.6	31	6.9P
4077.6	June 1	7.06_2
4078.6	2	7.28_2
4087.6	11	6.80_2
4089.6	13	6.81_3
4091.6	15	6.83_2

6682 *X Ophiuchi*—Cont.

Julian	Calendar	Mag.
	1897	
4094.7	June 18	6.7P
4097.7	21	6.8P
4098.6	22	7.17_2
4102.6	26	6.9P
4103.6	27	6.77_2
4108.6	July 2	6.97_2
4114.6	8	7.42_2
4115.6	9	7.0P
4121.6	15	7.0P
4140.6	Aug. 3	7.0P
4157.6	20	8.1P
4161.6	24	8.1P
4165.6	28	8.1P
4172.6	Sept. 4	8.3P
4201.5	Oct. 3	8.4P
4215.5	17	8.6P

6849 *R Aquilae.*

(Continued from 365.)

Julian	Calendar	Mag.
	1897	
4137.7	July 31	10.94_2
4159.6	Aug. 22	11.4
4163.6	26	11.92_2
4166.6	29	12.14_2
4170.5	Sept. 2	11.99_2
4185.5	17	11.91_2
4195.5	27	12.08_2
4211.5	Oct. 13	11.82_2
4213.5	15	12.19_2
4224.5	26	11.25_2

6871 *V Lyrae.*

(Cont from 393.Comp.Stars 393.)

Julian	Calendar	Mag.
	1897	
4176.5	Sept. 8	9.9]
4177.5	9	10.3]
4182.5	14	11.10_2
4189.5	21	11.00_2
4192.5	24	10.97_2
4195.6	27	11.08_2
4200.5	Oct. 2	10.82_2

6871 *V Lyrae*—Cont.

Julian	Calendar	Mag.
	1897	
4206.5	Oct. 8	11.00_2
4211.5	13	10.56_2
4216.5	18	10.94_2
4224.5	26	10.47_2
4228.5	30	10.85_2
4229.5	31	10.69_2
4241.5	Nov. 12	11.14

6888 *RW Sagittarii.*

(Continued from 393.)

Julian	Calendar	Mag.
	1897	
4094.7	June 18	9.7
4101.6	25	10.0
4103.6	27	10.31
4108.6	July 2	9.73_2
4111.6	5	9.86_2
4115.6	9	10.04_2
4128.7	22	10.14_2
4137.6	31	9.68_2
4142.6	Aug. 5	10.01_2
4161.6	24	9.4
4162.6	25	10.28_2
4165.6	28	9.67_2
4166.5	29	9.64_2
4167.6	30	9.57_2
4168.5	31	9.94_2
4169.6	Sept. 1	9.86_2
4170.5	2	9.67_2
4171.6	3	9.32_4
4172.6	4	9.28_2
4177.6	9	9.55_2
4178.5	10	10.65_2
4182.5	14	9.01_2
4183.5	15	9.13_2
4186.5	18	9.50_2
4189.5	21	9.48_2
4193.5	25	9.37_2
4195.5	27	9.50_2
4215.5	Oct. 17	10.1P

6892 *RX Sagittarii.*

(Continued from 393.)

Julian	Calendar	Mag.
	1897	
4094.7	June 18	9.1
4101.6	25	8.5
4103.6	27	9.67_2
4108.6	July 2	9.69_2
4111.6	5	9.81_2
4115.6	9	9.99_2
4128.7	22	11.23_2
4137.6	31	10.93_2
4142.6	Aug. 5	10.92_2
4161.6	24	13.0
4215.5	Oct. 17	12]P

6894 *S Lyrae.*

(Cont.from 393.Comp.Stars 339.)

Julian	Calendar	Mag.
	1897	
4052.6	May 7	11.0
4074.6	29	12.6
4224.5	Oct. 26	12.6]
4242.5	Nov. 13	12.6]

6900 *W Aquilae.*

(Cont.from 393.Comp.Stars 339.)

Julian	Calendar	Mag.
	1897	
4077.7	June 1	9.8
4078.7	2	8.75_2
4087.6	11	9.24_2
4101.6	25	9.60_2
4102.6	26	9.6P
4111.6	July 5	9.05_2
4114.6	8	9.31_2
4115.6	9	9.4P
4121.6	15	9.4P
4128.7	22	9.6P
4131.6	25	9.64_2
4140.7	Aug. 3	9.9P
4142.6	5	10.0P
4157.6	20	10.6P

COMPARISON-STARS.

5593 *W Librae.*

1893–1897

T	−15°4152		9.11	1*M*
Y	−15°4145		10.21	1*P*
a	8*s*1*p*	*d*	11.47	9
b	1*n*7*p*	*Y*	11.49	10
d	1*n*6*p*	*c*	11.48	12
j	2*n*5*f*	*V*	12.53	3
k	5*s*1*f*	*V*	12.47	3
l	2*s*3*f*	*V*	12.58	2

6160 *RT Herculis.*

T	+27°2777		9.59	9
U	+27°2774		9.61	13
W	+27°2767		9.75	9
Y	+26°2965		10.56	7
Z	+27°2775		10.92	9
a	2*n*8*p*	*U*	10.57	4
c	7*s*5*f*	*Z*	11.15	3
d	4*n*2*f*	*Z*	11.16	2

6682 *X Ophiuchi.*

1893–1897

E	+8°3797	6.96	33*M*
F	+8°3799	7.12	32
G	+8°3791	6.98	38
1*N*	+9°3789	8.12	13
T	+9°3793	9.00	11
1*T*	+9°3791	9.10	14
U	+8°3798	9.36	11
1*Z*	+9°3798	9.98	3

6888 *RW Sagittarii* and 6892 *RX Sagittarii.*

Q	−19°5353		8.65	24
4*T*	−19°5346		8.99	32
4*X*	−19°5349		10.08	27
a	4*s*2*f*	4*X*	10.62	12
b	4*n*4*f*	*RX*	11.01	3
c	3*s*	*Q*	11.40	5
e	3*n*3*f*	*a*	12.51	4
g	6*n*1*p*	*Q*	13.04	2

NEW ASTEROIDS.

Prof. **Kreutz** communicates the discovery of a new asteroid, 1897 *DK*, by **Villiger** at Munich, on Nov. 18, of $12^M.6$; with the following observations:

1897 Munich M.T.	App. α	App. δ	1897 Munich M.T.	App. α	App. δ
h m s	h m s	° ′ ″	h m s	h m s	° ′ ″
Nov. 18 12 12 48	4 27 49.04	+30 51 9.3	Nov. 18 13 46 40	4 27 44.13	+30 51 17.4
18 13 2 33	4 27 46.43	+30 51 13.9	19 6 40 16	4 26 56.64	+30 52 35.1

Also the discovery of one by **Charlois** as follows:

DL 12^M 1897 Nov. 23 $9^h\,45^m.6$ Nice M.T. $\alpha = 3^h\,19^m\,40^s$, $\delta = +13°\,47'$. Daily motion -52^s and $8'$ southward.

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE SAYRE OBSERVATORY, SO. BETHLEHEM, PA.,

By JOHN H. OGBURN.

1897 Bethlehem M.T.	*	No. Comp.	Planet — * Δα	Planet — * Δδ	Planet's Apparent α	Planet's Apparent δ	log Δp for α	log Δp for δ
			Emma (283).					
	h m s		m s	′ ″	h m s	° ′ ″		
Sept. 25	9 17 28	1	6	−0 57.08	+3 51.1	23 21 47.72	+ 7 30 6.2	n9.308	0.690
27	9 35 23	2	6, 5	+1 7.67	−7 35.7	23 23 16.59	+ 7 22 52.2	n9.186	0.687
			Ariadne (43).					
Oct. 15	9 9 51	3	8, 7	−0 15.05	+3 10.9	1 3 35.02	+12 51 15.0	n9.405	0.637
18	9 19 51	4	6, 5	−0 33.96	+3 43.1	1 0 39.08	+12 28 27.4	n9.325	0.634
			Athamantis (230).					
Oct. 18	9 43 28	5	5	−0 49.58	−7 0.0	1 36 9.41	+19 39 33.3	n9.381	0.537
Nov. 2	8 50 37	6	4, 5	−2 6.02	+2 5.0	1 23 44	+17 4 53	n9.308	0.570

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	23 25 40.53	+4.27	+ 7 25 44.3	+27.8	Göttingen 6666
2	23 22 4.66	+4.26	+ 7 30 0.1	+27.8	Göttingen 6639
3	1 3 45.52	+4.55	+12 47 34.3	+29.8	Münich I 596
4	1 1 8.48	+4.56	+12 24 11.3	+30.0	Münich I 572
5	1 36 54.26	+4.73	+19 46 4.9	+28.4	107 *Piscium*
6	1 25 45	+4.74	+17 2 18	+30.5	DM. 16°165

A CRITICISM OF SOME RECENT THEORETICAL RESULTS OF PROFESSOR WADSWORTH, RELATING TO THE THEORY OF TELESCOPIC IMAGES.

By J. M. SCHAEBERLE.

In his timely and instructive papers, recently communicated to the principal astronomical journals of both hemispheres, Professor Wadsworth arrives at some surprising results, some of which are based upon conclusions which I am wholly unable to accept as true.

One statement in particular whose truth I question is the following: *

"Now it follows at once from the principles of the wave theory that the intensity of illumination at the focal plane of an objective due to such an illuminated area (viz.: an area of infinite extent) will be simply proportional to the area of the objective — *i.e.* to the square of the linear aperture (b), and will be entirely independent of the focal length (f) of the instrument."

In No. 411 of the *Astronomical Journal*, Professor Wadsworth goes so far as to claim that because certain views heretofore held do not agree with his conclusions, "the error arises from making use of the principles of geometrical rather than physical optics," etc. Doubtless certain small errors are thus always introduced, and occasionally large ones, but so far as the application of these principles to a luminous area of infinite extent is concerned, I shall try to demonstrate, very briefly, that both the geometrical and physical laws lead to practically identical results.

In the August number of the *Astrophysical Journal* (to which reference is made in a foot-note), page 133, Professor Wadsworth obtains for the intensity of the field illumination due to a uniform luminous area of infinite extent, the expression,

$$\int_{-\infty}^{+\infty} d\xi \int_{-\infty}^{+\infty} I_1^2 d\eta$$

in which ξ and η are the coordinates of any point in the focal plane.

After stating that this integral is always equal to the area A of the aperture he arrives at the following conclusion: *

"In this case $A = \frac{\pi b^2}{4}$ and the intensity at every point in the field of a telescope due to a uniform luminous area of infinite extent (more strictly an area extending over an entire hemisphere) is, therefore,

$$i_{\text{III}} = \text{const. } b^2$$

---

* *Knowledge* for August, 1897, page 193. See also *M.N.* for June, page 587; and *Astr. Nachr.*, No. 3439.

* *Astrophysical Journal* for August, 1897, page 133.

or the illumination of the field is proportional simply to the square of the linear aperture of the telescope, and is entirely independent of the focal length and angular aperture of the latter."

In coming to this remarkable conclusion, Professor WADSWORTH has, as it seems to me, entirely overlooked the apparent fact that for a given aperture the value of I_1^2 in the above integral is not a constant, but varies inversely as the square of the focal length (nearly).

That this is so seems clear to me from the following considerations:

At any given point $\xi_1\,\eta_1$ in a plane whose focal distance is f the value of I_1^2 must evidently be regarded as a function of the angular distance θ of the point $\xi_1\,\eta_1$ from the optical axis. In general I_1^2 will decrease when θ increases. The above integral should, as it seems to me, therefore be regarded as expressing the total illumination of the focal plane, which according to the principle of the conservation of energy should (if we neglect the loss due to transmission, etc.,) equal the total illumination over an area equal in size to the objective and coincident with the latter.

Now, if f increases to f^1 the value of $\xi_1\,\eta_1$ (for a given value of θ) corresponding to the value of I_1^2 increases to $\xi^1\,\eta^1$, the value of I_1^2 must therefore decrease, for otherwise the total illumination of the focal plane would increase with increasing values of f; which is contrary to the known fact that the original supply of energy coming through the objective is constant.

It seems to me, therefore, that whether a large luminous area is of finite or infinite extent the intensity of the focal image (illumination) will not only vary as the square of the linear aperture, but also inversely as the square of the focal length of the telescope (nearly).

Lick Observatory, University of California, 1897 *Nov.* 8.

OBSERVATIONS OF COMET *b* 1897,

MADE AT THE GOODSELL OBSERVATORY, NORTHFIELD, MINN.,

BY H. C. WILSON.

Northfield M.T.	*	No. Comp.	☄ — *		☄'s apparent		log $p\Delta$	
			$\Delta\alpha$	$\Delta\delta$	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Oct. 22 7 33 28	1	10 , 6	+1 23.88	−1 27.1	2 42 36.17	+75 30 34.1	n0.213	8.682
9 11 38	2	8 , 6	+1 9.49	−0 14.2	2 41 34.44	+75 36 13.7	n0.118	n0.354
23 7 12 56	3	6 , 2	+1 49.60	+5 11.7	2 26 33.65	+76 49 44.1	n0.254	n8.920
7 12 56	4	6 , 4	+0 55.84	+3 8.8	2 26 32.13	+76 49 42.1	n0.254	n8.920
7 12 56	5	6 , 4	−1 50.20	+0 1.1	2 26 32.32	+76 49 42.0	n0.254	n8.920
25 11 1 18	6	8 , 6	+1 43.30	+9 58.4	1 37 13.97	+79 22 24.1	n9.218	n0.692
26 7 59 47	7	9 , 2	+3 6.83	−7 54.5	1 12 42.76	+80 11 39.7	n0.224	n0.536
7 59 47	8	9 , 2	+2 43.95	−9 50.4	1 12 42.66	+80 11 40.8	n0.224	n0.536
27 9 12 54	9	6 , 4	−6 2.86	−3 59.1	0 36 24.93	+80 59 14.1	n9.818	n0.695
29 7 57 22	10	9 , 6	+1 43.40	−4 20.7	23 17 19.41	+81 41 44.6	n9.759	n0.708
Nov. 1 9 44 5	11	10 , 6	+0 57.82	−6 16.6	21 18 31.84	+80 42 13.3	0.286	n0.491

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	2 41 1.35	+10.94	+75 31 42.3	+18.9	Northfield Meridian Circle, 2 obs.
2	2 40 13.99	+10.96	+75 36 8.9	+19.0	Northfield Meridian Circle, 2 obs.
3	2 24 32.76	+11.29	+76 44 11.6	+21.1	Northfield Meridian Circle, 2 obs.
4	2 25 24.95	+11.34	+76 46 12.3	+21.0	Northfield Meridian Circle, 2 obs.
5	2 28 11.11	+11.41	+76 49 20.3	+20.6	Northfield Meridian Circle, 1 obs.
6	1 35 19.15	+11.52	+79 11 58.9	+26.8	Northfield Meridian Circle, 2 obs.
7	1 9 24.72	+11.21	+80 19 4.7	+29.5	Northfield Meridian Circle, 3 obs.
8	1 9 47.48	+11.25	+80 21 1.8	+29.4	Northfield Meridian Circle, 3 obs.
9	0 42 17.42	+10.37	+81 2 41.3	+31.9	Northfield Meridian Circle, 3 obs.
10	23 15 31.16	+ 4.85	+81 45 29.0	+36.3	Northfield Meridian Circle, 3 obs.
11	21 17 38.10	− 4.08	+80 47 56.1	+33.8	Northfield Meridian Circle. 3 obs.

OBSERVATIONS OF D'ARREST'S COMET (*a* 1897),

MADE WITH THE 36-INCH REFRACTOR OF THE LICK OBSERVATORY, UNIVERSITY OF CALIFORNIA,

BY C. D. PERRINE.

1897 Mt. Hamilton M.T.	✳	No. Comp.	☄ − ✳		☄'s apparent		log *p*Δ	
			Δα	Δδ	α	δ	for α	for δ
	h m s		m s	′ ″	h m s	° ′ ″		
Aug. 8	15 19 14	1	*d* 10 , 8	−0 2.42	−0 43.2	3 41 35.76	+5 26 9.2	*n*9.525	0.687
22	16 11 14	3	3	. . .	+0 55.8	. . . .	+3 58 14.1	. .	0.689
22	16 17 50	3	*d* 6 ,	+0 9.95	. . .	4 5 1.91	. . . .	*n*9.294	. .
27	15 57 2	5	16 , 7	−0 55.55	+3 14.0	4 11 45.85	+3 19 37.7	*n*9.314	0.695
28	15 40 53	6	20 , 8	+0 18.15	−4 52.0	4 12 59.58	+3 11 31.8	*n*9.371	0.698
29	15 46 35	7	*d* 10 , 8	+0 16.72	−0 15.5	4 14 12.75	+3 3 13.1	*n*9.341	0.699
30	15 17 22	9	16 , 8	+1 58.21	+0 42.8	4 15 21.95	+2 54 57.7	*n*9.425	0.702
31	15 19 3	10	*d* 10 , 8	+0 2.95	−1 0.0	4 16 30.00	+2 46 27.6	*n*9.413	0.702
Sept. 1	14 46 49	12	*d* 10 , 8	−0 3.12	−1 48.1	4 17 34.66	+2 37 59.3	*n*9.487	0.707
1	15 54 21	12	*d* 10 , 8	−0 0.34	−2 11.2	4 17 37.74	+2 37 36.2	*n*9.281	0.702
25	13 43 54	13	*d* 10 , 8	+0 3.31	+1 57.0	4 32 26.42	−1 15 36.7	*n*9.449	0.733
Oct. 3	13 8 14	15	*d* 10 , 8	−0 3.00	−0 27.8	4 32 14.19	−2 37 36.9	*n*9.458	0.706

Mean Places for 1897.0 of Comparison-Stars.

✳	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 41 35.56	+2.62	+5 26 33.6	+18.8	Micrometer-comparison with ✳2
2	3 37 9.43	+2.64	+5 22 8.4	+19.1	Weisse's-Bessel 657
3	4 4 49.06	+2.90	+3 56 58.6	+19.7	Micrometer-comparison with ✳4
4	4 7 54.61	+2.88	+3 50 1.6	+19.5	Boss, Albany A.G. Catal. 1227
5	4 12 38.41	+2.99	+3 16 3.7	+20.0	Boss, Albany A.G. Catal. 1258
6	4 12 38.41	+3.02	+3 16 3.7	+20.1	Boss, Albany A.G. Catal. 1258
7	4 13 52.99	+3.04	+3 3 8.4	+20.2	Micrometer-comparison with ✳8
8	4 9 43.72	+3.06	+2 59 13.9	+20.4	Boss, Albany A.G. Catal. 1241
9	4 13 20.68	+3.06	+2 53 54.6	+20.3	Boss, Albany A.G. Catal. 1265
10	4 16 23.98	+3.07	+2 47 7.4	+20.2	Micrometer-comparison with ✳11
11	4 17 4.62	+3.07	+2 49 9.9	+20.1	Boss, Albany A.G. Catal. 1285
12	4 17 34.99	+3.09	+2 39 27.2	+20.2	Boss, Albany A.G. Catal. 1287
13	4 32 19.48	+3.63	−1 17 55.1	+21.4	Micrometer-comparison with ✳14
14	4 34 33.18	+3.62	−1 15 19.4	+21.2	Copeland-Börgen 1271
15	4 32 13.65	+3.84	−2 37 30.6	+21.5	Micrometer-comparison with ✳16
16	1 32 25.12	+3.84	−2 40 46.2	+21.5	Radcliffe (3) 1102

d Indicates that Δα was measured directly with the micrometer. Aug. 8 — Comet is easy to measure and has a well marked central condensation of about 10″ diameter. A star of 16^M is involved in outer nebulosity and may have influenced measures a trifle. Seeing poor. Aug. 22 — Comet not visible in dawn after Δα measures. Aug. 27 — Comet much fainter than on Aug. 8. Diameter 20″ to 30″; scarcely any condensation; $14^M - 15^M$. Wind swaying telescope at times. Aug. 29 — Comet not difficult. Aug. 31 — Sky very pure; comet is fainter. Sept. 25 — Comet faint, $15^M - 16^M$; not easy to measure. Oct. 3 — High wind; comet difficult. Oct. 4 — Comet not found. Oct. 24 — Looked for D'Arrest's comet but failed to see anything of it. Seeing very poor but field was fairly clear of stars.

CORRIGENDA.

No. 413, p. 39, col. 1, lines 5–9, in O—C, *for* — *put* +.
" 419, p. 87, col. 2, lines 6 and 7 from below, *strike out* sec 45°.
" " p. 87, col. 2, line 4 from below, *for* 1.22 *put* 1.16.
" " p. 88, col. 1, line 1, *for* "place containing" *put* "plane containing this axis and."
" " p. 88, col. 1, line 4, *for* 66″ *put* 48″.
" " p. 88, col. 1, line 4, *for* "minute" *put* "⅔ minute."

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OBSERVATIONS OF THE VARIABLES *Z HERCULIS* AND *Y CYGNI*, WITH RESEARCHES ON THEIR PERIODS,

By N. C. DUNÉR.

6442. *Z Herculis.*

Epoch	Greenwich M.T.	Observer
538	1897 Aug. 23^{d} 10^{h} 7^{m}.3	Dunér
539	Aug. 25 8 27	"
547	Sept. 10 7 59	"
559	Oct. 4 7 6	"
569	Oct. 24 5 45	"

Combining these observations with the minima that I observed in 1894, I have obtained the following formulas:

Even minima, $1894 + 257^{d}.368 + 1^{d}.996377\,E$
Odd minima, $1894 + 257.315 + 1.996373\,E$

In its ordinary brilliancy, the star has always appeared to me as $0^{M}.2$ brighter than the comparison-star DM. +14°3378, whose magnitude is 7.32, according to Prof. MÜLLER at Potsdam. At principal minimum it was $0^{M}.3$ brighter than DM. $+14°3375 = 8^{M}.43$. At secondary minimum it was exactly equal to DM. $+14°3374 = 7^{M}.55$. With these data we should have,

Normal brightness $= 7^{M}.12$
Secondary minimum $= 7.55$
Principal minimum $= 8.13$

The periods that I have found being almost exactly equal to that of Mr. HARTWIG, $1^{d}.996370$ the difference amounting only to $0^{s}.7$ and $0^{s}.3$, respectively — we shall now be able to examine the reason why Mr. PICKERING has vainly sought to observe the secondary minimum. The cause of this is that the ephemeris that I had given was somewhat in error on account of the small interval embraced by my observations in 1894. The corrections of this ephemeris are:

Even minima, $+1^{h}\ 37^{m}$
Odd minima, $+1\ 33$

The ephemeris of Mr. HARTWIG, although giving the even minima correctly, was still more erroneous than mine for the odd minima, its correction being $+2^{h}\ 14^{m}$. Consequently the photometric observations at the Harvard College Observatory were begun too soon, and ended before the variation assumed an unequivocal character. However, in examining the original observations, which Mr. PICKERING has kindly sent me, I can distinguish with certainty the diminution in the brightness of the star toward the end of the observations.

In my note on this star, in No. 384 of the *Astronomical Journal*, there is an expression which might well cause misapprehension, if one did not recall what I have written in my note in the *Astrophysical Journal*, 1895 April, p. 285. In fact, it seems, from what Mr. HARTWIG has said in the introduction to the ephemerides of variable stars for 1897, that he thought, or presumed that it might be thought, that I had wished to claim to have independently discovered the *existence* of the secondary minima of *Z Herculis*. That I had never any such intention, and had formally declared that Mr. HARTWIG had alone discovered them, is proved by the following words in my note already cited: "I received Mr. CHANDLER'S ephemeris on Sept. 12, but on account of unfavorable weather I was unable to observe a minimum until Sept. 18. In the meantime (on the 15th) a telegram arrived from Prof. HARTWIG, announcing that he had discovered the variability of the same star, and that its period was $1^{d}\ 23^{h}\ 55^{m}\ 40^{s}$." But what I did discover was the nature of the system *Z Herculis*; that is to say, that it consists, not of a bright and a dark body, like *Algol*, nor of two bodies of the same size and brightness, like *Y Cygni*, but of two bodies of the same size of which one has only half the brightness of the other; and that consequently, as I have said in the *Astrophysical Journal* for 1895, p. 294: "*Z Herculis* . . . . forms a hitherto missing link between the stars of the pure *Algol*-type and *Y Cygni*." Such is the meaning of my expression in No. 384 of the *Astronomical Journal*, "the theory which I have proposed."

7188. *Y Cygni.*

Epoch	Greenwich M.T.		d	h	m	Observer
1654	1893	Sept.	21	12	4.8	Dunér
1897	1894	Sept.	20	7	29.7	"
1919		Oct.	23	6	39.5	"
1923			29	6	45.7	"
2282	1896	Apr.	19	9	55.0	Bohlin
2286			25	9	27.0	"
2290		May	1	8	52.0	"
2355		Aug.	6	11	11.1	Dunér
2355			6	11	9.5	Bergstrand
2359			12	11	4.5	"
2365			21	11	4.5	"
2369			27	10	59.5	"
2371			30	10	49.5	"
2383		Sept.	17	10	17.0	Bohlin
2385			20	10	25.2	"
2391			29	9	35.4	"

Mr. BOHLIN remarks that the observations in the spring are uncertain on account of the small altitude of the star. Especially, he cannot fix precisely the time of the minima 2282 and 2290, but merely that they did not occur later than the times above given. However, I find them to be in good agreement with the observations of Mr. YENDELL during the autumn and winter of 1895, and I have employed them in the formation of the normal minima. With the help of these observations and the normal minima which I have formed with all the published observations since 1886, I have obtained the following formulas:

Even minima, $1886 + 343^{\mathrm{d}}.4799 + 1^{\mathrm{d}}.498219\,E$

Odd minima, $1886 + 343.3919 + 1.498124\,E$

Upsala, 1897 *Dec.* 1.

The residual errors are:

Even Minima			Odd Minima		
Epoch	O—C	Obs.	Epoch	O—C	Obs.
	d			d	
12	−0.019	5	191	+0.002	11
118	+0.021	1	705	+0.011	17
952	(−0.092)	4	1187	−0.003	13
1184	−0.006	28	1311	−0.003	10
1610	+0.027	17	1649	(−0.061)	5
2208	−0.018	8	1913	−0.011	3
			2371	+0.001	9

Aside from the two excluded epochs, the agreement is sufficient, and there is yet no reason for introducing a term depending on the square of the time. However, this will sooner or later become necessary; since without it the time which elapses between successive even and odd minima would become in the end nothing. We may accordingly, perhaps, expect that the even minima will occur sooner, and the odd minima later than in the following ephemerides, which are given for Greenwich mean time.

Even Minima						Odd Minima					
Epoch			d	h	m	Epoch			d	h	m
2686	1897	Dec.	15	16	42.5	2685	1897	Dec.	13	20	30.0
2706	1898	Jan.	14	15	51.3	2705	1898	Jan.	12	19	36.9
2726		Feb.	13	15	0.0	2725		Feb.	11	18	42.9
2746		Mar.	15	14	8.7	2745		Mar.	13	17	48.9
2766		Apr.	14	13	17.5	2765		Apr.	12	16	54.9
2786		May	14	12	26.1	2785		May	12	16	0.8
2806		June	13	11	34.8	2805		June	11	15	6.8
2826		July	13	10	13.5	2825		July	11	14	12.8
2846		Aug.	12	9	52.5	2845		Aug.	10	13	18.8
2866		Sept.	11	9	1.0	2865		Sept.	9	12	24.7
2886		Oct.	11	8	9.6	2885		Oct.	9	11	30.6
2906		Nov.	10	7	18.3	2905		Nov.	8	10	36.6
2926		Dec.	10	6	27.1	2925		Dec.	8	9	42.6

OBSERVATIONS OF LONG-PERIOD VARIABLES,

BY PAUL S. YENDELL.

5677. *R Serpentis.*

I have twelve observations of this star, from 1897 Aug. 2 to Sept. 24, which indicate that a bright maximum was passed on Aug. 21.

At the first observation, the estimated brightness of the star was $8^{\mathrm{M}}.2$, at the maximum, $6^{\mathrm{M}}.3$, and at the last date, $8^{\mathrm{M}}.0$.

5768. *RR Herculis.*

From 1897 May 4 to Oct. 23, I observed *RR Herculis* nineteen times. At the first observation, the star was estimated to be of the $9^{\mathrm{M}}.1$; on June 21 it had increased to $8^{\mathrm{M}}.3$; at the next observation, on July 8, and on July 21, it was observed as $9^{\mathrm{M}}.2$, and on Aug. 5, had again risen to $8^{\mathrm{M}}.4$, from which date it steadily declined, being estimated as $9^{\mathrm{M}}.7$ at the last observation. In view of several known cases of confusion with comparison-star *a* (DM. 50°2250) it seems probable that the two apparently discordant observations in July may have been simple cases of misidentification, and the curve has therefore been drawn without regard to them. The maximum indicated by this curve falls on July 3.

6005. *S Draconis.*

From 1897 May 23 to Oct. 23, I have made seventeen observations of *S Draconis*, which show a well-defined minimum of $10^{\mathrm{M}}.0$ on Aug. 6. The brightest light observed previous to the minimum was $8^{\mathrm{M}}.3$ on June 2, and on Sept. 24 it had risen to $8^{\mathrm{M}}.7$, at about which light it was found at the last date.

6733. *R Scuti.*

Twenty-one observations of *R Scuti*, from 1897 June 18 to Oct. 23, show a single well-defined minimum at $7^{\mathrm{M}}.5$ on Sept. 28. A bright minimum of $6^{\mathrm{M}}.2$ seems to have taken place, probably about June 30, and a maximum of about 5^{M} somewhere near July 30, but as only one observation was obtained between June 27 and Aug. 3, these dates are uncertain, especially the maximum. The observed brightness of the star on June 18 was $5^M.2$, and on Oct. 23, $6^M.5$.

7257. *R Sagittae.*

I have observed *R Sagittae* twenty-three times between 1897 June 16 and Oct. 23. This series, though badly interrupted by the weather, indicates with tolerable distinctness two minima, apparently principal, on July 3 and Sept. 11, and a slight depression, possibly a secondary minimum, about Aug. 5. Fairly distinct maxima are shown about June 20, July 29, and Sept. 29.

8324. *V Cassiopeae.*

Twelve observations of this star, from 1897 Aug. 5 to Oct. 23, indicate a maximum of $7^M.6$ on Sept. 11.5. At the first and last observations the star was estimated as $9^M.8$.

8369. *W Pegasi.*

Eleven observations, from 1897 Aug. 5 to Oct. 17, show rather uncertainly a maximum of $8^M.2$ on Aug. 17. The first observation, on Aug. 5, found the star at $8^M.3$. The next two days later showed a rise of $0^M.1$, and at the third, Aug. 20, the star was estimated as $8^M.2$. The remaining observations show a slow and steady decline to $8^M.8$, at the last date.

It will be seen from these particulars, that although the date assigned is uncertain, the indication is pretty distinct that the maximum must have occurred not many days from the first of August.

Dorchester, Mass., 1897 Dec. 7.

THE LEONIDS OF 1897,

By E. E. BARNARD.

I had made careful preparations to photograph the Leonid meteors this year, but the very bad weather prevented any observations.

The following notes may be of interest as possibly having a slight negative value.

1897 Nov. 11. Cloudy in first part of night. Cleared beautifully at midnight. From then until $17^h\ 15^m$ one meteor only was seen during frequent watches.

Nov. 12. Cloudy first part of night. Clear at 14^h. From this time on till $17^h\ 35^m$ not a single meteor seen.

Nov. 13. Cloudy at dark. A large portion of the sky cleared at $5^h\ 50^m$ p.m. For half an hour fairly clear, then broken until $7^h\ 30^m$, when it clouded densely. Cloudy and raining the remainder of the night. No meteor was seen during the partly clear spell in the early evening.

Nov. 14. The clouds broke away from $6^h\ 0^m$ to $6^h\ 30^m$ p.m. Then densely clouded. At $8^h\ 30^m$ a few stars seen through thin places. Clearing away at $8^h\ 45^m$, but misty, and then closed in again at $9^h\ 0^m$. Sky watched closely during these breaks, but no meteor seen. At the second break, anything as bright as the 3^M or 4^M would have been seen through the thin mist. Densely cloudy, with frequent rains the rest of the night. On these last two nights I was on watch all night until $18^h\ 30^m$.

Nov. 15. Cloudy first part of night, clearing from north at $15^h\ 30^m$. Broken from this on until daylight. Watched at intervals for meteors. Two Leonids of 4^M seen, one at $16^h\ 0^m$, the other at $16^h\ 45^M$.

Yerkes Observatory, 1897 Nov. 19.

OBSERVATIONS OF (11) *PARTHENOPE,*

MADE AT THE CINCINNATI OBSERVATORY,

By EVERETT I. YOWELL.

1897 Cincinnati M.T.	*	No. Comp.	Planet — * $\Delta\alpha$	Planet — * $\Delta\delta$	Planet's Apparent α	Planet's Apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
h m s			m s	′ ″	h m s	° ′ ″		
Sept. 20 8 57 48	1	9	−1 8.59	+4 54.4	1 16 29.90	+0 16 14.7	n9.617	0.744
21 8 49 49	1	8	−1 51.83	−1 51.9	1 15 46.68	+0 9 28.5	n9.619	0.744
22 9 37 23	2	8	−1 49.37	−3 11.4	1 15 0.10	+0 2 21.4	n9.559	0.745
25 9 27 3	3	8	+0 46.33	−3 56.2	1 12 40.87	−0 18 5.6	n9.553	0.746
28 9 31 46	4	8	+0 34.13	+6 36.4	1 10 13.13	−0 38 43.5	n9.521	0.750
Oct. 1 10 23 53	5	8	+0 58.17	+0 1.7	1 7 37.82	−0 59 4.7	n9.354	0.753
27 9 44 17	6	8	−1 16.85	+2 39.6	0 46 26.26	−3 9 9.6	n8.845	0.771

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 17 34.23	+4.26	+0 10 51.3	+29.0	Göttingen I, 286–7; Karlsruhe
1	1 17 34.23	+4.28	+0 10 51.3	+29.1	Göttingen I, 286–7; Karlsruhe
2	1 16 45.18	+4.29	+0 5 3.7	+29.1	Göttingen I, 282–3
3	1 11 50.21	+4.33	−0 14 38.6	+29.2	Göttingen I, 262–3
4	1 9 34.64	+4.36	−0 45 49.2	+29.3	Bonn VI, −0°190
5	1 6 35.25	+4.40	−0 59 35.8	+29.4	Göttingen I, 254–5; Karlsruhe
6	0 47 38.61	+4.50	−3 12 17.7	+28.5	Cincinnati Meridian Circle

OBSERVATIONS OF COMET *b* 1897,

MADE AT THE LICK OBSERVATORY OF THE UNIVERSITY OF CALIFORNIA.

By WILLIAM J. HUSSEY.

1897 Mt. Hamilton M.T.		*	No. Comp.	☄ − * Δα	☄ − * Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Oct. 16	13 7 15	1	5	. . .	+7 21.1	. . . .	+67 0 16.8	. .	0.630
17	7 23 59	2	8 , 8	−0 19.68	−0 13.6	3 30 50.69	+68 10 58.8	*n*0.098	0.402
	7 44 14	3	3	. . .	+0 31.4	. . . .	+68 12 18.9	. .	0.299
	12 37 49	4	8 , 8	−0 51.73	+0 57.7	3 29 26.75	+68 31 26.6	*n*9.549	0.633
18	7 29 7	6	8 , 8	−1 7.12	+2 58.5	3 24 2.15	+69 43 53.5	*n*0.130	0.286
19	7 16 10	7	12 , 8	+0 50.20	−2 52.6	3 15 51.55	+71 16 22.5	*n*0.160	9.983
	8 25 50	7	8 , 8	+0 37.03	−0 16.3	3 15 11.38	+71 18 58.8	*n*0.146	*n*9.250
20	7 47 26	8	8 , 8	+0 36.91	−4 21.5	3 6 23.19	+72 46 15.2	*n*0.193	9.729
	10 3 2	8	8 , 8	−0 21.90	+4 5.4	3 5 24.35	+72 54 12.1	*n*0.061	*n*0.486
23	10 21 44	10	1	. . .	−6 38.7	. . . .	+77 6 3.1	. .	*n*0.688
	10 28 28	10	8	+0 11.51	. . .	2 22 31.71	. . . .	*n*9.956	. .
24	8 53 8	11	10 , 10	−2 2.56	+0 29.3	2 3 28.36	+78 14 23.1	*n*0.200	*n*0.588
	12 10 45	12	. .	+0 33.21	−3 36.6	2 0 17.80	+78 21 45.5	9.117	*n*0.760
	13 36 57	12	8 , 8	−0 50.80	+0 35.9	1 58 53.79	+78 28 58.0	0.018	*n*0.696
27	8 12 4	13	8 , 8	−0 22.15	−7 9.4	0 31 12.55	+81 1 26.7	0.035	*n*0.750
	12 16 20	15	8 , 8	+1 50.65	−7 55.7	0 28 31.25	+81 6 47.8	0.227	*n*0.693
28	13 45 22	16	8 , 8	+0 14.17	+0 28.4	23 15 53.22	+81 34 11.8	0.470	*n*0.263
29	7 26 40	17	8 , 8	−0 13.44	−6 1.6	23 14 12.09	+82 40 6.0	*n*0.060	*n*0.772
30	9 12 31	18	8 , 8	−0 14.01	−1 54.8	22 28 56.12	+81 36 18.7	0.179	*n*0.727
31	13 16 25	19	8 , 8	+0 18.18	−4 25.8	21 44 10.68	+81 9 38.2	0.482	0.108
Nov. 1	12 2 46	21	8 , 8	+1 47.75	−1 28.8	21 12 55.74	+80 35 2.1	0.453	9.264
12	6 53 45	22	4	. . .	+6 25.0	. . . .	+69 57 13.9	. .	*n*0.285
	6 58 36	22	5	+0 10.07	. . .	18 47 30.91	. . . .	0.049	. .
15	7 57 26	24	8 , 8	+0 3.60	−0 36.9	18 35 27.47	+67 2 9.5	0.065	9.703
16	8 5 5	26	5 , 6	−0 14.87	+2 16.0	18 32 20.40	+66 6 50.6	0.055	0.000

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	3 36 15.60	+ 8.33	+66 52 11.3	+11.4	Christiania A.G. Catal. 623
2	3 31 1.71	+ 8.66	+68 11 0.3	+12.1	Connected with *3
3	3 41 35.15	+ 8.72	+68 11 33.8	+10.7	Christiania A.G. Catal. 641
4	3 30 9.74	+ 8.74	+68 30 16.7	+12.2	Connected with *5
5	3 31 15.68	+ 8.77	+68 29 28.7	+11.6	Christiania A.G. Catal. 622
6	3 25 0.20	+ 9.07	+69 40 12.4	+12.9	Christiania A.G. Catal. 604
7	3 11 54.81	+ 9.54	+71 19 0.8	+14.3	Johnson's Radcliffe Catal. 925
8	3 5 36.22	+10.03	+72 50 21.1	+15.6	Connected with *9
9	3 14 46.53	+10.13	+72 50 28.9	+14.4	Becker. 521 stars, 79
10	2 22 11.68	+11.52	+77 12 20.4	+21.4	DM. 77°84, Tucker, meridian-circle obs.
11	2 5 19.16	+11.76	+78 13 30.3	+23.5	DM. 78°74, Tucker, meridian-circle obs.
12	1 59 32.83	+11.76	+78 27 58.0	+24.1	DM. 78°70, Tucker, meridian-circle obs.
13	0 34 21.74	+ 9.96	+81 8 3.6	+32.5	Connected with *14
14	0 34 51.38	+10.05	+81 13 31.8	+32.1	Carrington. 83
15	0 26 34.07	+ 9.53	+81 12 10.5	+33.0	Carrington, 59
16	23 15 31.70	+ 7.05	+81 33 8.1	+35.3	Carrington. 3668
17	23 15 20.33	+ 5.20	+82 15 31.4	+36.2	Carrington. 3580
18	22 29 8.63	+ 1.50	+81 37 37.0	+36.5	Carrington, 3459
19	21 44 21.05	− 1.55	+81 13 28.8	+35.2	Connected with *20
20	21 52 0.82	− 1.07	+81 11 8.9	+35.6	Carrington, 3348
21	21 11 11.32	− 3.33	+80 35 57.6	+33.6	Schwerd. 1260
22	18 47 21.11	− 3.27	+69 50 33.0	+15.9	Connected with *23
23	18 44 5.06	− 3.29	+69 19 20.0	+15.1	Christiania A.G. Catal. 2900
24	18 35 26.55	− 2.68	+67 2 33.2	+13.2	Connected with *25
25	18 36 54.36	− 2.66	+67 3 29.1	+13.5	Christiania A.G. Catal. 2881
26	18 32 37.74	− 2.47	+66 1 22.0	+12.6	Connected with *27
27	18 34 5.55	− 2.47	+66 1 18.6	+12.8	Christiania 2870

The second and third observations of Oct. 24, and those of Oct. 31 and Nov. 15, were made with the 36-inch, and all the others with the 12-inch telescope. The second observation of Oct. 24 was by position-angle and distance: the second of Oct. 17 and that of Oct. 16, by transits; in all other cases $\Delta\alpha$ and $\Delta\delta$ were measured directly with the micrometer.

When discovered the comet had a distinct stellar nucleus and a decided condensation. After a few days these disappeared, the comet increased in apparent size, and became faint and difficult to observe. Towards the end of the series of observations it presented no well-marked place upon which to set the micrometer-wire. In November a region at some distance from the head was somewhat brighter than the rest of the comet, and of such appearance that it might readily be mistaken for the head.

As seen in the large telescope the tail was about 2′ or 3′ long at discovery, and about 5′ long at the end of October. On Oct. 17 its length was fully 10′ on a photograph which I obtained. The following measures of the position-angle of the tail were made:

Mt. Hamilton M.T.	
d h m	°
Oct. 19 8 36	203.6
24 12 30	216.2
31 12 15	211.4

Mt. Hamilton, Cal., 1897 *Dec.* 6.

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE OBSERVATORY OF VASSAR COLLEGE,

BY MARY W. WHITNEY AND CAROLINE E. FURNESS.

1897 Greenwich M.T.	*	No. Comp.	Planet − * $\Delta\alpha$	Planet − * $\Delta\delta$	Planet's Apparent α	Planet's Apparent δ	log Δp for α	log Δp for δ	Obs.
(116) *Sirona.*									
h m s			m s	′ ″	h m s	° ′ ″			
Apr. 29 17 54 30	1	8	+1 39.11	+ 7 18.1	14 51 35.18	−14 11 58.3	8.910	0.862	F
May 7 14 1 42	2	11	+0 48.16	− 8 19.7	14 44 31.53	−13 51 19.7	*n*9.451	0.840	F
8 16 33 35	2	9	−0 10.71	− 5 36.1	14 43 32.67	−13 49 6.1	7.839	0.861	F
(118) *Gallia.*									
May 29 18 16 31	3	8	−0 20.95	+ 5 23.4	16 5 51.87	+15 31 45.2	9.315	0.608	W
31 19 1 11	4	11	−0 30.91	+ 4 20.7	16 4 12.53	+15 30 52.5	9.472	0.633	W
June 1 15 37 27	1	9	−1 12.39	+ 3 38.7	16 3 31.05	+15 30 10.7	8.880	0.591	W
(33) *Polyhymnia.*									
June 1 16 18 17	5	10	−0 35.01	+ 0 47.8	16 36 15.13	−24 53 37.2	*n*8.802	0.907	F
2 15 35 34	5	9	−1 34.93	+ 2 17.9	16 35 15.22	−24 52 7.2	*n*9.253	0.902	F
(113) *Amalthea.*									
June 1 14 48 23	6	8	−0 15.76	+ 1 9.1	15 39 38.97	−11 24 48.4	*n*9.090	0.845	T*
2 14 58 19	6	8	−1 37.26	+ 1 15.6	15 38 47.18	−11 24 41.8	*n*8.978	0.846	T
(283) *Emma.*									
Sept. 27 14 54 52	7	4	+1 7.46	7 16.9	23 23 16.37	+ 7 22 37.7	*n*9.027	0.697	W
28 14 54 34	7	9	+0 22.68	−11 24.9	23 22 31.59	+ 7 18 59.8	*n*8.992	0.697	W
29 15 39 1	8	7	+0 54.14	+ 1 54.3	23 21 49.46	+ 7 15 11.5	*n*7.441	0.697	W
(179) *Klytaemnestra.*									
Sept. 29 14 39 47	9	7	+1 43.78	− 8 36.7	0 29 49.60	+15 17 43.6	*n*9.388	0.620	W
30 14 59 51	10	6	+2 5.02	+ 1 38.0	0 29 3.39	+15 11 34.5	*n*9.303	0.612	W
Oct. 2 14 48 24	11	9	+0 27.68	− 6 15.4	0 27 32.35	+11 59 1.8	*n*9.271	0.612	W

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	s	
1	14 49 52.96	+3.11	−14 18 57.9	−18.5	Cambridge, Mass., Zones, 1 obs.
2	14 43 40.18	+3.19	−13 43 11.1	−18.9	*μ Librae*; ¼[Rad. '90, 3830 + Cord. 20,088 + Gr. 10 yr., 1880, 2287 + C.G. Hope '80, 8069]
3	16 6 9.59	+3.23	+15 26 34.8	−13.0	Auwers, Berlin A.G.C. 5783
4	16 4 40.19	+3.25	+15 26 44.1	−12.5	Auwers, Berlin A.G.C. 5773
5	16 36 46.27	+3.87	−24 54 12.4	−12.6	Cordoba Zones, 2471
6	15 40 21.26	+3.47	−11 25 41.7	−15.8	Klinkerfues-Schur 3784
7	23 22 4.65	+4.26	+ 7 29 56.8	+27.8	Glasgow I. 6186
8	23 20 50.76	+4.26	+ 7 12 49.3	+27.9	Klinkerfues-Schur 6628
9	0 28 1.44	+4.38	+15 25 51.5	+28.8	½[Berlin A, 154 + Glasgow I, 149]
10	0 26 53.98	+4.39	+15 9 27.5	+29.0	½[Berlin A, 142 + Glasgow I. 143]
11	0 27 0.26	+4.41	+15 5 17.9	+29.3	Berlin A. 143

* MARY TARBOX, graduate student.

Planet (120) *Lachesis.* Correction to Ephemeris (*Veröff. R. I.* No. 5). Nov. 23. +20ˢ +1′.0.

NOTE ON THE PROPER MOTION OF BRADLEY 2444$''$ = 3250,

By J. G. PORTER.

The proper motion of this star as computed by Dr. Auwers (see preface of Auwers's Bradley) is $+0^{s}.0040$, $+0''.128$.

I have been able to avail myself of a much longer series of observations, which, while it confirms the small motion in right-ascension, negatives entirely the quite considerable motion given for the declination. Indeed, Dr. Auwers's result seems to have been due to a wrong reduction of the declinations of D'Agelet and Lalande.

I append my table of positions reduced to the A.G. system. In deriving the motion I have relied principally on the modern observations.

Authority	Epoch	R.A. 1900	P.M. applied	No. obs.	Epoch	Decl. 1900	P.M. applied
		h m s	s			° ′ ″	″
Bradley,	1752.6	19 17 12.47	12.82	1 , 0	–	−0 26	
D'Agelet,	84.0	13.24	13.52	2	1784.0	31.1	34.6
Lalande,	94.5	12.85	13.10	1	94.5	27.8	31.0
Weisse's Bessel,	1821.6	12.83	13.02	1	1821.6	29.8	32.1
Henderson,	14.6	12.90	13.03	3 , 2	44.7	29.8	31.5
Munich,	50.0	12.89	13.01	9	50.0	27.8	29.3
Pulkowa,	58.5	12.91	13.01	5	58.5	29.3	30.6
Bonn,	60.5	12.89	12.98	1	60.5	28.0	29.2
Santini,	62.6	12.96	13.05	1	62.6	31.0	32.1
Schjellerup,	63.5	12.91	13.00	1	63.5	27.5	28.6
Göttingen,	67.6	13.03	13.11	2	67.6	30.9	31.9
Greenwich 9-yr.,	68.6	12.92	13.00	3	68.6	29.2	30.1
Bruxelles,	73.4	13.01	13.07	4 , 5	73.6	30.3	31.1
Romberg,	75.0	12.96	13.02	6	75.0	29.6	30.4
Cordoba,	77.6	12.93	12.98	4	77.6	29.4	30.1
Greenwich 10-yr.,	78.6	12.95	13.00	3	78.6	30.4	31.0
Radcliffe,	84.3	12.93	12.97	3	84.7	30.5	31.0
Cincinnati,	1897.1	19 17 13.01	13.02	2	1897.1	−0 26 30.1	30.2
		P.M. $+0^{s}.0024$				P.M. $-0''.030$	

EPHEMERIS OF MINOR PLANET (387), 1893 AZ.

By JOHN H. OGBURN.

12^{h} Berlin M.T.	App. α	App. δ	log Δ	12^{h} Berlin M.T.	App. α	App. δ	log Δ
1898	h m s	° ′ ″		1898	h m s	° ′ ″	
Jan. 1	7 37 35.60	+13 20 47.7	0.3843879	Jan. 15	7 25 5.85	+14 35 6.9	
3	7 35 51.54	13 30 41.7		17	7 23 18.27	14 46 27.2	0.3811585
5	7 34 5.85	13 40 52.5	0.3822229	19	7 21 31.82	14 57 53.6	
7	7 32 18.89	13 51 18.7		21	7 19 46.85	15 9 24.5	0.3826288
9	7 30 31.04	14 1 58.7	0.3809556	23	7 18 3.77	15 20 58.4	
11	7 28 42.65	14 12 51.1		25	7 16 22.94	+15 32 33.8	0.3849833
13	7 26 54.14	+14 23 54.3	0.3805983				

Opposition January 12. Mag. $11^{M}.0$.

ELEMENTS OF COMET *b* 1897.

By R. TRACY CRAWFORD.

From observations made at the Lick Observatory, and sent to the Students' Observatory by Prof. J. M. Schaeberle, Acting Director, I have computed the following sets of parabolic elements for comet *b* 1897; the first set from observations by Mr. Perrine on Oct. 16 and 17, and by Prof. Hussey on Oct. 18; and the second set from the observation of Oct. 16, and two by Prof. Hussey on Oct. 31 and Nov. 15.

The value of log M (0.064621) used in determining the second set was derived from the first set, and agrees exactly with that derived from the second set, so that the second set of elements must be considered as the best parabolic orbit which can be passed through the given observations.

	1st Set	2d Set	
$T =$	1897 Dec. 8.86570	Dec. 8.550029 Gr. M.T.	
	° ′ ″	° ′ ″	
$\omega =$	66 6 41.1	65 48 38.0	
$\Omega =$	32 3 21.0	32 2 56.6	1897.0
$i =$	69 35 39.5	69 35 51.5	
$q =$	1.355513	1.357331	
$l\lambda \cos\beta =$	$-0''.3$	$+11''.7$	
$l\beta =$	$-1\ .0$	$+19\ .6$	
$\cot J =$	$n9.818048$	$n9.238929$	
$\cot J_0 =$	$n9.818044$	$n9.238926$	

LIST NO. 5 OF NEBULAS DISCOVERED AT THE LOWE OBSERVATORY.

BY LEWIS SWIFT.

No.	Date	R.A. (1900)	Decl. (1900)	Description
	1897	h m s	° ′ ″	
1	Nov. 19	1 2 37	−18 2 35	vF, pS, R, np of 2
2	19	1 2 45	−18 0 35	B, eS, lE, almost stellar, sf of 2
3	Oct. 30	1 11 21	−31 41 22	eeF, vE 350°, 5st. sf have dist. comp.
4	Nov. 26	1 19 45	+ 8 12 55	eF, pS, R, 10^{M} att p. st with dist. comp. sf an, np
5	Oct. 30	1 35 29	−29 26 15	eeF, eS, R, B st in margin of field
6	Nov. 17	1 44 23	−33 16 18	eeF, pS, R, 2F st p point to it
7	26	1 50 45	+ 5 11 7	pF, pS, R, 9^{M} near np
8	17	1 53 5	−32 29 45	eF, pS, R, Cordoba 681 sp
9	25	2 47 10	−33 14 50	eeeF, vS, lE, eee dif, 7^{M} in field sf
10	Oct. 19	2 49 5	−34 36 55	eF, S, R
11	Nov. 25	3 11 25	−33 14 53	eeF, pS, lE, 7 or 8 pB st n
12	Oct. 3	3 26 20	−44 27 0	pB, pS, R
13	Nov. 17	3 32 30	−44 19 10	eeeF, vS, eeE, a ray 90°, pB st f
14	Oct. 3	3 39 10	−40 12 46	eF, pL, R, 2 st nr f, wide D np
15	Nov. 19	3 43 0	−34 2 0	eF, L, cE, $7^{M}.5$ in contact nearly obliterates it
16	Oct. 3	3 50 20	−36 17 6	pB, S, R, st nr nf, D st sp
17	Nov. 19	4 6 30	−39 58 0	eeeF, pS, R, e dif, 9^{M} f same parallel
18	19	5 15 35	−37 12 58	pB, eS, R, 3 st in line np
19	26	5 20 25	−27 4 38	eeeF, vS, R, eee dif
20	Dec. 1	5 27 5	−23 8 20	eeF, pS, R, 7^{M} nr sf
21	Oct. 7	5 42 30	−18 13 12	eeF, pS, eE, 45° ∆ sf
22	7	5 48 30	−17 53 11	vF, pL, R, v wide D st nr p
23	22	23 10 29	−43 8 24	pB, pS, R, 8^{M} p same parallel
24	Nov. 19	23 29 0	−36 39 0	eeeF, vL, bet 2 st, D st p 45^{s} little s, pentagon p
25	Oct. 19	23 33 58	−23 4 30	eF, pS, $7^{M}.5$ st 19^{s} sf partly obscures it = 18042 Weiss's Argelander

NOTES.

A few of the above objects are quite interesting, notably numbers 15 and 24, especially the latter. Of the former it seems strange, although in close contact if not partly superimposed on the star, that it was not long ago found. I think it would, could it be detached from the star, be quite an interesting one. It is of No. 24 I wish more particularly to speak, as it is a remarkable object. It appears to be a nebulous nebula, if such an expression be allowable. Its appearance was as if a central, considerably elongated nebula with sharp outlines, was centrally superimposed on another nebula very much larger, and of unimagined faintness. It was impossible, the seeing being excellent, to assign limits to the outer envelope. It is the largest and among the faintest of all my nebulas. I have requested the Director of the Lick Observatory to examine it with the 36-inch telescope.

No. 24 of list 3 = 37 of list 1.
No. 26 of list 3 = 39 of list 1.

ELEMENTS OF THE ORBIT OF (194) *PROKNE.*

BY C. J. MERFIELD.

Preparatory to computing an ephemeris and the differential coefficients of the equations of condition for the purpose of correcting the orbit-elements of this asteroid, provisional elements were computed with normal places constructed on the dates 1897 Aug. 14, 1897 Aug. 29, and 1897 Sept. 13.

The normals were obtained by correcting the ephemeris, given in the supplement to the *Berliner Jahrbuch* of 1899, by the equations

$$\Delta\alpha = 76^{s}.301 + [8.65702]\,t - [8.02621]\,t^2$$
$$\Delta\delta = 45''.76 \;- [9.50425]\,t - [8.60981]\,t^2$$

the quantities within brackets being logarithms, and t equals $T_0 - 27$ Aug. Berlin mean time.

These equations result from the solution of fifteen equations of condition in the form

$$a + bt + ct^2 = r$$

the absolute term being the residual found by comparing fifteen observations with the ephemeris mentioned. The observations were taken by Mr. J. TEBBUTT, F.R.A.S., of Windsor, N.S.W., and kindly communicated to the writer in manuscript.

ELEMENTS.

Epoch 1897 Aug. 27.0 G.M.T.

$$\begin{array}{rcl} & & \;\;\circ\quad\;\prime\quad\;\;\prime\prime \\ M & = & \;\;9\;\;10\;\;26.03 \\ \omega & = & 160\;\;22\;\;49.32 \\ \Omega & = & 159\;\;16\;\;\;\;5.59 \\ i & = & \;\;18\;\;41\;\;51.73 \end{array}\left.\vphantom{\begin{array}{c}\omega\\\Omega\\i\end{array}}\right\}\text{Mean Eq. 1897}$$

$$\begin{array}{rcl} \phi & = & 13\;\;59\;\;24.38 \\ \mu & = & 827''.7283 \\ \log a & = & 0.4214125 \end{array}$$

Middle place $(C - O)$ $\Delta\alpha = -0^s.005$ $\Delta\delta = -0''.6$

$$x = [9.9971854]\, r \sin(v + 50^\circ\ 39'\ 22''.60)$$
$$y = [9.9977319]\, r \sin(v + 321\ 19\ 36.79)$$
$$z = [9.1833907]\, r \sin(v + 272\ 55\ 27.04)$$

accenting ω, Ω and i to denote these quantities for the year 1900, then

$$\omega' - \omega = +1''.07\ .\quad \Omega' - \Omega = +149''.77\ .\quad i' - i = -1''.39$$

These elements will give some idea of the corrections necessary: no doubt observations of this planetoid at previous oppositions are available, and will be used in the final corrections.

Sydney, N.S.W., 1897 Nov. 2.

NEBULAS NEAR *CASTOR*.

BY E. E. BARNARD.

In 1888, when we first went to Mt. Hamilton, and before the completion of the Lick Observatory, I found quite a number of new nebulas with the 12-inch equatorial. Among these were five within less than a degree of *Castor*. The positions of these nebulas were determined by equatorial pointings — carefully corrected by pointings on *Castor* — before the micrometer could be used.

These nebulas are interesting on account of their closeness to this well-known star, and I have taken them from a list of unpublished new nebulas which I have in hand, waiting for star catalogues to complete the positions of a number of those which were micrometrically observed, before publication.

These nebulas near *Castor* were all discovered on 1888 May 9, except No. 1, which was found May 12 of that year. They were all subsequently seen.

Yerkes Observatory, Williams Bay, Wisconsin, 1897 Dec. 18.

The positions here given are reduced to 1860.0, the epoch of DREYER'S New General Catalogue.

No.	α	δ	Description
	h m s	° ′	
1	7 21 23	+31 44.4	close p. 10ᴹ star
2	7 24 43	+31 35.5	small, faint
3	7 25 12	+31 40.5	small, 3 8 ✶s in curve 2′ p ±
4	7 25 27	+31 40.5	very, very faint
5	7 25 59	+31 31.0	small, faint

This close clustering together of a few nebulas in isolated spots is a remarkable feature which I have come across a number of times. I have discovered several nests of these similar to this one near *Castor*. In most of the other cases, however, the individual nebulas are very much smaller.

It is now nearly ten years since these nebulas were discovered, and I regret that they were not published sooner.

MERIDIAN-CIRCLE OBSERVATIONS OF COMPARISON-STARS, FOR COMET *b* 1897,

BY R. H. TUCKER.

DM. No.	R.A. 1897.0	Decl.	Mag.	Epoch
	h m s	° ′ ″		
78°70	1 59 32.83	+78 27 58.0	8½	1897.82
78°74	2 5 19.16	+78 13 30.3	9¼	1897.82
77 84	2 22 11.68	+77 12 25.4	7½	1897.84

NOTICE.

A moderate number of copies of the *Third Catalogue of Variable Stars* are still available, and will be distributed gratuitously to those interested in the subject, on application to the Editor of this Journal.

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THE PARIS CONFERENCE AND THE PRECESSIONAL MOTION* (Second Paper),

By LEWIS BOSS.

The object of this communication is to supplement my remarks upon the propositions of the Paris Conference of 1896 (*A.J.* 410); and to explain more fully, in answer to the objections of Professor Newcomb (*A.J.* 413), why I think his investigation of the precessional motion ought not to be regarded as definitive. On the latter point, though not in a formal way, and not in strict logical order, I shall virtually support these general propositions:

First. There is no emergency calling for the immediate adoption of new values of the precessional motion, because there is every reason why there should be a period of increased activity in this line of research. Investigations in stellar problems will probably characterize the astronomy of the twentieth century, as research upon the solar system has been the most remarkable feature in the astronomy of the century now closing.

Second. The study of the precessional motion ought to be more effectively connected with the definitive solution of problems concerning solar motion, structure of the sidereal system, and general systematic errors in observed star-positions, — all of which ought really to constitute a single general and indivisible problem.

Third. Material of observation on the brighter stars already exists in rich abundance for a much more comprehensive investigation of the processional motion than that which is presented in Prof. Newcomb's paper; zone-observations of the fainter stars can also be usefully employed in the study of this problem; and with comparatively little exertion the value of the existing evidence can be very greatly enhanced by further observations now.

Professor Newcomb's investigation deserves special attention because we are not only to consider it as a contribution to knowledge, but also because we are virtually called upon forthwith to adopt the results which he has reached. Indeed, these results, through the action of the Paris Conference, were predestined for acceptance, and it may be surmised that they have actually been adopted in the preparation of some of the Almanacs for 1901. That this claim upon the general acceptance of astronomers is regarded as a settled matter is sufficiently evident from the published record of the Conference and from Professor Newcomb's paper (*A.J.* 405). Now, I submit that it is unusual, if not quite altogether unprecedented, to put forward a claim like this, prior to, or simultaneously with, the first publication of a scientific investigation. Heretofore, the general assent of astronomers to the use of any one particular evaluation of an astronomical constant, or element of computation, has been a matter, not of negotiation, or decree, but of examination and judgement. Through the latter method Professor Newcomb himself has been most appropriately honored more than once.

It may be that, in the concluding paragraph of his reply, Professor Newcomb intended to intimate that I have questioned the wisdom of the Paris Conference in intrusting the investigation of the precession to him rather than to another. I should be very sorry indeed to suppose that Professor Newcomb really means to be interpreted in this way, because it would not only indicate how much he underestimates the respect for his scientific ability which everywhere prevails, but it would also indicate that he does not perceive the force of the real objection.

Now, if there is any one principle more than another for which Science has been strenuously contending during three centuries, it is that truth shall be accepted not because of the weight of authority behind it, but because of the power of the testimony upon which it rests. Accordingly, if the Conference, upon the topics considered, assumed to legislate for astronomy in general, it not only assumed to exercise an authority which was never conferred upon it, but also an authority which, in the nature of things, could not have been conferred. I have assumed, however, that the Conference did not profess to act in a plenary sense for astronomers in general; though the practical effect is much as it might have been had it actually made such profession. The directors of the four Almanacs enjoy a virtual monopoly of permanent ephemeris computation. If they combine to decide what values of astronomical constants shall be employed in each and every one of these publications, it is evident that by such action they, of necessity, exert a very strong pressure upon the computing practice of astronomers in general. Under such circumstances, some astronomers, though disapproving the action of the Conference, might hesitate to oppose what they might regard to be inevitable.

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* The delay in this rejoinder to Professor Newcomb's remarks (*A.J.* 413) might seem rather great, were it not that it is the consequence of an expectation that contributions from others would render it unnecessary.

For this reason, I consider it to be the duty of every earnest and intelligent astronomer to withstand with uncompromising firmness any such infringement upon the free spirit of scientific research. With all due respect and courtesy for the distinguished astronomers who composed the Paris Conference, I consider their propositions now freely open to discussion, and with the distinct understanding that the final decision, if any decision can be reached, shall depend upon the fairly accordant opinions of astronomers in general.

Before I proceed to comment in detail upon Professor Newcomb's last paper, I must call attention to the fact that he does not there defend the action of the Paris Conference as to its conclusions upon anything except the precession. Yet the question as to what aberration-constant shall be adopted is a very important one; because, of late, investigation on that point has been very active. The general drift of recent testimony appears to have been in favor of a value of the constant of aberration larger than that which the Paris Conference adopted, — perhaps as large as 20″.50. There is manifestly much curiosity upon this point; and it would be a grave misfortune, if the disposition to continue such investigations should receive an untimely check.

In the outset of his remarks in *A.J.* 413 Professor Newcomb expresses the suspicion that a certain amount of misapprehension may be caused by the use of the phrase, "Constant of Precession." Professor Newcomb himself has freely employed this phrase (or its equivalent), and has even entitled the work here under discussion, "The Precessional Constant;" so that it is not quite clear to me whether or not he means to deprecate the further use of the term. I think, however, that the employment of that phrase is a loose use of language; and although almost every one must perceive its limitations, the further use of the term ought, perhaps, to be discouraged.

This affords me occasion to repeat that the result of a discussion of the precessional motion may depend very much upon the point of view that is taken in the solution. To make this more definite, let us take a geometrical conception of the precessional motion without reference to the physical causes which produce it. The very large and growing interests of stellar astronomy demand some such view as that which considers the precession as merely the consequence of the motion of two points in the usual system of celestial coordinates, — the pole and the equinox. In case these two motions should be considered to be independent of each other each might be independently determined by observation.

Stellar astronomy must come to this eventually; but, owing to the present difficulty of dealing with the planetary precession and the secular terms of precession otherwise than through the theory of perturbations, it may be doubted whether the time is yet ripe for such a departure from the customary method. It may be assumed, then, that we shall, for the present, rely upon theory to establish a definite relation between these two motions, such that either of them can be computed when the other is known for any epoch from observation. The question will then arise as to what weight shall attach to the respective measures of the two motions.

In order to examine this point more conveniently let us consider the equations,

$$\begin{aligned} \psi \cos\omega - \lambda &= m \\ \psi \sin\omega &= n \end{aligned}$$

in which ψ and λ are repectively the luni-solar and planetary precessions, ω is the obliquity of the ecliptic, in our problem assumed to be known, and m and n have the meanings usually attached to them in the formulas for computing precession in right-ascension and declination. If n be determined by observation, not only ψ, but also m, become known; while m is also directly determined by measurement of the right-ascension component of the motion of the equinox. Thus, with the assumptions made as to ω and λ, we may determine the motion of the equinox without observing the sun at all. Now, while it is impossible to construct a system of star-declinations and motions which shall be absolutely free from suspicion of periodic error of the form, $\kappa \cos\alpha$. I am sure that this can be so nearly accomplished, that the determination of ψ from n shall be fairly comparable in precision with that arising from the direct determination of m. This is what I meant in my former paper (*A.J.* 410) by the importance of the "point of view" in studying the precessional motion.

The uncertainty in direct measurement of the motion of the equinox, though sufficiently evident, is apt to be ignored by investigators of precession when estimating the relative precision in determination of ψ through m and n respectively. It is true that Professor Newcomb appears to appreciate this point; but he, nevertheless, actually proceeded as if his chief concern was with the right-ascensions. He attaches some value to the precession-determination by Dr. Dreyer, derived through a comparison of the right-ascensions of Lalande and Schjellerup; while, though apparently aware[*] of the value of Dr. Bolte's exactly corresponding work upon declinations, he gives it no weight whatever in making up his result. In his work, "The Constant of Precession," pp. 68 to 73, Professor Newcomb does show some inclination to reconcile the value of $d\psi$ which he derives through right-ascensions with the corresponding result from declinations; but he seems to me to do this in a half-hearted manner, and to be chiefly anxious to demonstrate that the value of $d\psi$ which he finally adopts is substantially consistent with the corrected result from right-ascensions; so that, after all, he uses the value of $d\psi$ from n merely as a suggestion as to further examination and treatment of the result through m.

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[*] "The Precessional Constant," p. 9.

Stating the point in a broader way, it seems to me that the determination of precession ought not, as heretofore, virtually to depend upon the observed right-ascensions of equatorial stars, but should take into account stars distributed over the entire sky and should lay as much stress upon the declinations as upon the right-ascensions. In this way we shall be able, and ought, to include with the discussion of the precessional motion a simultaneous and intentionally definitive determination, not only of the elements of that, but also of the error in the provisionally adopted motion of the equinox, the constants of the solar motion, and the nature of the dependence of the final results upon the observed positions of stars, — comparing and contrasting the testimony from stars classified according to proper motion and magnitude. All the probabilities seem to indicate that Science has a right to expect the production, within comparatively few years, of general investigations such as I have described. The publication of the *Gesellschaft* zones will naturally provoke such discussions; and it seems to me entirely reasonable to suggest that we should await the appearance of such discussions, before inviting general agreement upon the adoption of a new value of the precessional motion.

Professor Newcomb apparently does not anticipate that satisfactory investigations like that described in the preceding paragraph will make their appearance within something like a half century to come. He seems to think that Astronomy is now about to go into a sort of decline, a species of middle, or dark ages, during which the spirit of originality, in an energetic and capable form, will be practically dead. He defines his view clearly in these words: "I do not think it will be possible to make the probable error [as to the precession] materially smaller until we have at command the results of observations and researches *not likely to be available for thirty or perhaps fifty years*" (*A.J.* 413, p. 35). The italics are mine.

The general acceptance of this opinion in its connection with the Paris Conference would carry consequences of unusual moment; for it would mean severe discouragement, if not positive disapproval, of any attempt to investigate precessional motion during the next thirty to fifty years. Let us see what there is in Professor Newcomb's work, and in his objections, to warrant a proposition so radical.

His determination is based upon only two out of the scores of elaborate series of observed star-positions which are available. I must refer to my previous paper for some comments upon this point (*A.J.* 410). I merely wish to add here that no one would now think the instruments which Bradley used at all suited to the delicate task of precise determinations of star-positions. Observation made with them at the present time would be so distrusted for the possibility of anomalous systematic error that it is doubtful if they would be given any weight in comparison with the best contemporary observations. The distance in time and the isolation of Bradley's observations give them a real value; but their actual precision then is no greater than it would be now. As to the second of the series of determinations employed by Professor Newcomb (Greenwich 1865 ±), it is one of the best we have, but its date is already thirty years back, admirably suiting it to be chosen as an ancient epoch with which to compare observations to be made within the next decade.

But Professor Newcomb objects that he did not rely on those two series of observations alone, since he corrected the proper motions arising from their use by systematic corrections ascertained by means of a large number of other authorities. No one could read his paper without understanding this; but the trouble is, as I suggested in my previous article, that for observations like those which were made with the rude instruments of past times, even by the greatest of observers, it is impossible to arrive at more than a rough approximation to the systematic errors which they contain. Professor Newcomb in various publications has borne testimony to this fact, and in the article now under consideration (*A.J.* 413), and in reference to the very point under discussion, he says: "The reality of the corrections for reduction to the Boss-system is, therefore, subject to grave doubt. I attribute the discrepancy less to errors of either set of declinations than to the accumulation of accidental differences in the case of individual stars. This conclusion illustrates the danger of concluding that a mean difference between the co-ordinates of two catalogues indicates a systematic difference, unless the number of stars of comparison is considerable." Certainly that danger is very great, and constitutes one of the many cogent reasons why, in this stage of the progress of astronomy, it is not wise to base a discussion of the precessional motion upon only two series of observations. The force of Professor Newcomb's reasoning in the last complete paragraph on page 34 of his paper (*A.J.* 413), cannot be fully appreciated until he shall have exhibited the process by which he deduced the positions and motions of the 800 stars of his catalogue which are in common with Bradley, and until it is known to what extent his proper motions have been influenced by Bradley's observations.

Professor Newcomb also seems to imply that of the brighter stars, outside of those observed by Bradley, there are none available for a study of the precessional motion; and, consequently, that our only alternative is to have recourse to the older zone-observations. Before assent is given to this view, some attention should be devoted to the star-catalogues produced between 1820 and 1850, at Greenwich, Dorpat, Edinburgh, Oxford, Armagh, Madras, St. Helena, Cape of Good Hope, and elsewhere. Even in their present condition, these catalogues afford the positions for a mean epoch of 1835, of 12000 to 15000 stars with an average weight for the whole of them which, at the least, is two or three times that due to Bradley's places. Cutting this list down to 6000 or 8000 stars, it is quite certain that these positions, combined with good modern determinations, ranging in mean epoch from 1875 to 1900 as required, would afford the means of computing proper motions that would not be sensibly inferior to the Auwers-Bradley determinations, even in the casual sense. In using this material for a discussion of the precessional motion we should have, in addition to the greater number of stars, two advantages of the highest importance. First, the stars would be distributed over the entire sky from pole to pole, permitting separation of precessional and solar-parallactic motion in the solution, with an independent test of the general systematic corrections. Secondly, the danger of unknown systematic errors in the star-positions would be very much less than it possibly can be, with any precautions which can be taken, when Bradley alone is used for the first epoch in the computation of proper motion. In fact the period 1820–1850 is richer than any other in the history of astronomy in fundamental determinations of a high class. We have, for instance, the determinations made by Bessel at Königsberg, and that by Argelander at Abo, together with those made at Greenwich, Dorpat, Pulkowa and the Cape of Good Hope.

There are about 15000 stars of the magnitude $7^{M}.0$, or brighter. For a large fraction of these satisfactory values of the proper motion can be computed now; while for the remainder accurate observations made within the next decade would suffice to place them in the same category. Valuable additions to this list could be drawn from the 11000 stars of magnitude $7^{M}.0$ to $7^{M}.5$. Thus we have, or soon may have, plenty of material for studying the precessional motion without having recourse to the very faint stars.

The proposed new reductions of Piazzi's numerous observations of 7646 stars, and of Taylor's observations of 11015 stars, now in progress, should add very materially to the force of the foregoing remarks; and it is to be hoped that other similar undertakings may be carried to a successful conclusion within the next ten years. As to the re-observation of the brighter stars, this is urgently needed for many reasons; much of this sort of work has been recently done; and much more is in progress.

Professor Newcomb objects to the use of the fainter stars in discussion of the precessional motion because he thinks proper motions of sufficient accuracy cannot be computed for them individually; because the systematic errors of the older zone-observations cannot be determined with sufficient precision; and especially because, to quote his own words, "we meet with the insuperable difficulty that they (observations of faint stars in right-ascension) are vitiated by variation of personal equation with magnitude." Undoubtedly, it is not easy to extract adequate information about the precessional motion from observation of the faint stars alone. Yet it would probably be conceded that it is more desirable to have our knowledge of precession based upon observations of the more distant stars if practicable; because the proper motions of those stars would be smaller and, therefore, any lack of symmetry in the distribution of them would produce a smaller distortion in the coefficients of the observation-equations. While some of the faint stars are very near us, the great mass of them are more distant than the mass of brighter stars. It is also of interest to determine through observation of the more distant stars whether the same apex of relative solar motion applies to them as to the nearer stars, — those having larger proper motion. We therefore need the testimony to be derived from the multitudes of fainter stars having practically insensible proper motions, individually considered.

What may actually be accomplished by employing only zone-observations of fainter stars may be illustrated from the precession-researches of Dr. Dreyer and Dr. Bolte. Comparing the declinations of Lalande with those of Schjellerup and arranging the results in three groups according to magnitude we have the following statement, which exhibits in the last column Dr. Bolte's determination of $65\,\Delta n$, n being his adopted constant, $20''.0578$, for the epoch 1830.

Group	No. stars compared	$65\,\Delta n$
M M		″
5.5 to 7.4	804	−0.40
7.5 to 8.2	1224	−0.36
8.3 to 10.	1048	−0.31

No star is here rejected on account of large proper motion. The agreement of the values of $65\,\Delta n$ is remarkably good, and one cannot help feeling that, if a similar discussion were to be extended to tens of thousands of stars, and to dozens of series of observations easily available, it would constitute a most welcome contribution to knowledge. But the objection can be made that the above results are subject to material systematic errors, and this is, in fact, the case. Δn is independent of a constant difference in the comparison, but it is different if either of the catalogues has a systematic error of the form, $\kappa \cos \alpha$. It appears that Piazzi's declinations, upon which Lalande's are based, are subject to a periodic systematic error. This was investigated by me in my catalogue of 500 stars (p. [98]); also for 143 stars within the Albany zone (*A.J.* 195); also for Lalande, directly, through 212 observations within the Albany zone (*A.J.* 195). The three determinations are as follows:

Source	Correction
Piazzi, generally,	$-0''.18 \cos \alpha \;\; +0''.53 \sin \alpha$
Piazzi–Albany zone,	$-0.14 \cos \alpha \;\; +0.36 \sin \alpha$
Lalande–Albany zone,	$-0.25 \cos \alpha \;\; +0.29 \sin \alpha$

Now each of these determinations is founded upon what must be regarded as very slender material in comparison with that which is available and in relation to the importance of the problem of precession; yet the agreement of the several coefficients must be regarded as quite satisfactory. Therefore, in connection with other experiences of a similar nature, I find ground for believing that there is not much greater uncertainty in determining the luni-solar precession from star-declinations than there is in determinations from the motion of the equinox.

I remark, in passing, that my interpretation of Dr. Bolte's work results in practically destroying, or, rather, slightly reversing his indication of a rotation of the stellar sphere about the poles of the galaxy. I find the correction to Struve's value of n for 1830 to be $-0''.0033$; while Professor Newcomb's interpretation of Dr. Dreyer's work corrects Struve's m for 1830 by $-0''.0066$. The resulting correction to the Struve–Peters ψ for 1800 is $-0''.0077$ (resulting $\psi = 50''.3721$); the corrections through m and n being, respectively, $-0''.0072$ and $-0''.0083$.

The comparison of the zones of Lalande and Bessel with the Albany zone, excluding all stars which appear to have proper motion exceeding $0''.1$, indicates clearly and certainly the effect of solar-parallactic motion with a very respectable approximation to the coordinates of the solar apex as determined from stars having large proper motions. This is a very delicate test, because the coefficients are all less than $2''.0$ per century, and, of course, still less for the interval of observation.

Dr. Ristenpart, in a more elaborate way, has also presented evidence* which tends greatly to strengthen the opinion that the older zone observations are capable of service in questions of refinement which do not demand a high degree of accuracy in the individual star-places. (*Const. der Praec. und die Bew. der Sonne., u.s.w.*, Dr. F. Ristenpart, Karlsruhe, 1892).

In each of the three researches to which allusion has just been made, there was employed less than one-twentieth of the weight of testimony which will soon be derivable from a comparison of the older zones with modern observations; and the promise as to the value of that testimony which these merely tentative researches indicate has long impressed me with the conviction that, whenever the testimony is drawn upon in a comprehensive and exhaustive way, with intelligence, it will yield answers of the greatest weight to all questions concerning precession, solar motion, and related problems. The new reduction of Piazzi's and Taylor's observations combined with a comparatively small amount of additional modern observations, after the publication of the *Gesellschaft* zones, will enable us to discuss with advantage the systematic errors of the older zone-observations, and thus to make this great mass of testimony available.

But here Professor Newcomb would interpose another objection which relates to personal equation varying with star-magnitude. A great many of the Bradley-stars are comparatively faint; a large fraction of the whole number is composed of stars fainter than $6^{M}.0$; and, therefore, this objection by Professor Newcomb applies in some degree to his own discussion. But it must be admitted that this objection is much more serious in its relation to the faint stars. It is very difficult, however, to understand why Professor Newcomb singles out personal equation varying with star-magnitude as presenting an "insuperable" barrier to investigation. The astronomy of the present day can by no means afford to admit this. In his paper, contained in *A.J.* 369, Professor Newcomb comes to the conclusion that both chronographic and eye-and-ear observations are about equally affected by this form of personal equation. It

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* Dr. Ristenpart compared the zones of Bessel with the Berlin northern zones (Becker), the mean interval being only 54.5 years. The arrangement of the stars upon which he bases his discussion in a zone of mean declination, $+22^\circ.5$, is very unfavorable for discrimination between the effects of precession and solar motion. In researches of this kind it is virtually indispensable that the stars employed should be symmetrically distributed on either side of some great circle of the celestial sphere. Dr. Ristenpart finds, however, for the luni-solar precession for 1800, $50''.3633$, $0''.0165$ less than the Struve–Peters value. For the coordinates of the solar apex derived from stars having proper motion less than $0''.1$ he finds

$$A = 294^\circ.3 \quad ; \quad D = +28^\circ.2$$

In a rough revision of Dr. Ristenpart's equations, allowing for Dr. Becker's personal equation for star-magnitude, $-0^{s}.007$ $(M-4)$, adjusting to the system of the principal stars of the *American Ephemeris*, and combining the equations in such a manner that the coordinates of the solar apex shall depend upon 454 stars having apparent proper motion greater than $0''.1$, while the correction to the Struve–Peters ψ shall be derived from the remaining 4565 stars, I find for ψ (1800), $50''.3528$, and for the apex of solar motion: $A = 295^\circ.4$; $D = +39^\circ.0$. The correction of ψ (Struve–Peters) through m was $-0''.0203$; through n it was $-0''.0404$; adopted, $-0''.0271$. But the result for precession is quite sensitive to whatever assumption is made as to solar-parallactic motion, — a difficulty which would be almost entirely removed by performing a like computation upon a zone at the mean declination $-22^\circ.5$, and combining the results with this.

seems to me that this conclusion is in need of verification before it shall be accepted. So far as my own limited examination of the question goes it leads me to results at variance with those of Professor Newcomb.

A few of the right-ascensions of Albany (chronographic) have been compared with nearly contemporaneous results obtained by eye and ear in at least three instances which are on record, the testimony of which may be briefly summarized. In the following little table, the numbers in the last column entitled, "Corrn. of eye and ear R.A." are the observed corrections necessary to be applied to the respective right-ascensions computed from transits by eye and ear in order to make them agree with Albany right-ascensions derived from chronographic transits that have been corrected for variation of personal equation with magnitude in the manner recommended in the introduction of the Albany Zone Catalogue. The standard right-ascensions are the same for all the series.

R.A. by eye and ear obtained at	No. stars compared	Mean magn.	Corrn. of eye and ear R.A.
		M	
Albany*	13	8.8	[−0.016]
Liege†	26	9.1	0.000
Munich‡	691	8.8	−0.007

Some time ago I made a careful comparison of the right-ascensions (chron.) of the Albany Catalogue with those of Romberg's Pulkowa Catalogue (eye and ear). Each is based on the same system of standard right-ascensions; the epochs are near together; and careful allowance was made for proper motion where it was known to exist. The results depend upon the comparison of 254 stars, having usually four observations in the Pulkowa Catalogue and two or three in the Albany Catalogue; and they may be expressed in summary thus:

Mean magn.	No. of stars	Albany−Pulkowa uncorrected	Albany−Pulkowa corrected
M		s	s
5.34	75	+0.021	+0.003
7.71	123	+0.042	−0.011
8.97	56	+0.057	−0.014

The numbers in the column "uncorrected" are derived from the catalogue-places as they stand; the numbers in the column, "corrected" result when each right-ascension of the Albany Catalogue has been corrected by $-0^s.0087\,(M-4) - 0^s.0012\,(M-4)^2$, the correction found from screen observations (See Int. Alb. A.G. Zone-Cat. p. (18)). It may be worth while to point out that this formula results from concordant observations about equally distributed in three separate years. My personal experience with these observations was such as to inspire confidence in them. I cannot see why this measurement should not be as reliable as any other of like apparent weight for any other purpose; and therefore I cannot now admit that the determination of this form of personal equation presents "insuperable" difficulties to any observer of fair experience. I by no means deny that a determination of this kind is subject to the ordinary chance of casual and systematic error, which in this instance may well amount to $0^s.01$, and possibly to $0^s.02$, for a star of the ninth magnitude.

From the four comparisons I have here presented the actually indicated correction for transits derived through eye and ear is insignificant ($-0^s.01$); and it is, therefore, strikingly at variance with Professor Newcomb's inference in regard to the Pulkowa Catalogue in question (*A.J.* 369).

Recurring again to the general topic relating to determination of the precessional motion I wish to suggest that a new and ingoing investigation of the motion of the equinox appears to be desirable. The investigation made by Newcomb a quarter of a century ago was exhaustive for its time, but new evidence has accumulated since, not all of which has been brought to bear upon the problem; and we may confidently look for still more valuable observations from several observatories within the next ten years. Furthermore it may be desirable to investigate the practical effect upon the determination of this element exerted by the variation of latitude, as suggested with such force by Dr. Chandler (*A.J.* 284, p. 154).

In fact, from every point of view, the present time seems to me singularly inopportune for the adoption of a new evaluation of the precessional motion.

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* Proc. Am. A.A.S. Vol. xxviii, 1879, p. 117. The weight of this comparison is feeble.

† DeBall. *Catalogue de 382 étoiles faibles*, pp. 59 and 60.

‡ Bauschinger, Int. *Neue Ann. Mün. Stw. Bd.* II.

OBSERVATIONS OF COMET *b* 1897,

MADE WITH THE 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY,

By HERBERT R. MORGAN.

1897 Eastern M.T.		∗	No. Comp.	☄ − ∗ Δα	☄ − ∗ Δδ	☄'s apparent α	☄'s apparent δ	log pΔ for α	log pΔ for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Nov. 17	9 34 27	1	4	. . .	−4 44.1	. . . .	+65 16 49.9	. .	n1.139
	9 48 14	1	16	−1 12.08	. . .	18 29 42.06	. . . .	0.032	. .
18	8 10 53	3	11 , 4	+1 39.79	−2 53.6	. . . .	. . . .	0.028	0.802
19	9 53 56	5	*d* 4 , 4	+0 6.13	−2 11.4	18 25 4.50	+63 33 24.8	9.995	n1.035
20	8 1 9	6	12 , 4	−1 18.77	−3 51.1	18 23 16.35	+62 49 0.9	0.001	0.904
23	7 9 44	8	24 , 4	+0 51.12	+1 14.8	18 18 38.41	+60 32 18.9	9.953	0.332
24	7 14 8	9	16 , 4	−3 1.60	−0 50.0	18 17 18.43	+59 49 46.6	9.949	0.533
27	7 26 24	10	12 , 2	−2 1.88	−1 12.1	18 14 15.02	+57 49 49.0	9.934	1.036

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	18 30 56.47	−2.33	+65 21 22.0	+12.0	Christiania A.G. 2858
2	18 25 7	−2.22	+61 33.8	+10.8	DM. +64°1268
3	18 25 23	−2.20	+64 29.9	+10.8	Micrometer-comparison with *2
4	18 32 12.24	−1.98	+63 37 10.1	+11.7	Krüger, A.G. Catal. 9869
5	18 25 0.40	−2.03	+63 35 25.7	+10.5	Micrometer-comparison with *4
6	18 24 37.03	−1.91	+62 52 41.8	+10.2	Krüger, A.G. Catal. 9798
7	18 24 36.42	−1.50	+60 24 55.7	+ 9.4	Krüger, A.G. Catal. 9796
8	18 17 48.54	−1.55	+60 30 55.8	+ 8.3	Micrometer-comparison with *7
9	18 20 21.47	−1.44	+59 50 28.2	+ 8.4	Krüger, A.G. Catal. 9771
10	18 16 18.07	−1.17	+57 50 54.3	+ 6.8	Krüger, A.G. Catal. 9738

NOTES. — The comet was exceedingly faint on all of the nights of observation. No nucleus was seen. The wires were put, as near as possible, tangent to the preceding end. *d* indicates that $\Delta\alpha$ was measured directly with the micrometer.

$*3 - *2$; $\Delta\alpha = +16^s.31$; $\Delta\delta = -3' \, 51''.5$.

ON THE ABERRATION OF PARABOLIC MIRRORS,

BY J. M. SCHAEBERLE.

In his article in *A.J.* 420, Dr. POOR makes some statements which call for remarks from myself.

First, to make plain that which is "obscure" in my formulas, let what I have elsewhere called the *blurring factor* be given by the expression,

$$(1) \qquad \frac{\text{Dist. from focus to farthest point of image}}{\text{Dist. from focus to nearest point of image}}$$

all distances being measured in the focal plane. Using my own notation, *A.J.* 413, we can at once write the *rigorous* equations,

$$(2) \qquad \text{Greatest distance} = \rho \tan\theta \sec(v+\theta)$$

$$(3) \qquad \text{Least distance} \quad = F \tan\theta$$

Consequently,

$$(4) \quad \text{Blurring factor} = \frac{\rho}{F}\sec(v+\theta) = \frac{1}{\cos(v+\theta)\cos^2\frac{1}{2}v}$$

When θ is small we can write, in place of the *theoretically rigorous* expression (4), the approximate equation

$$(5) \qquad \text{Blurring factor} = \frac{1}{\cos v \cos^2\frac{1}{2}v}$$

which, for the ordinary purpose of illustrating the magnitude of the errors to which I have called attention, is sufficiently approximate.

To show how slight the difference is between the results given by my rigorous and approximate formulas, even for large values of θ, I have, as an example, computed the following values of the angular amount of the blurring for different ratios of focal length to aperture, for $\theta = 30'$.

Ratio of Focal Length to Aperture	Rigorous Formula	Approximate Formula
	″	″
5	15.1	13.5
6	10.4	9.2
7	8.1	7.0
8	6.3	5.4
10	4.3	3.4
14	2.3	1.4
18	1.6	1.1
22	1.1	0.7

Dr. POOR is in error when he assumes that his formulas (which have doubtless been derived since the publication of my investigation in *A.J.* 413) are general and exact; they are exact only for the single special case of aberration in the plane containing the optical axis and the point whose image is under consideration. In like manner my simple *rigorous* formula (4) gives only the aberration along a line drawn in the focal plane from the focal point.

The aberrations in other directions are always less, reaching a minimum, both in the spherical field and focal plane, in a direction at right angles to a line drawn from the image to the focal point.

Dr. POOR is therefore in error in his "*Conclusion*" when he states that "The image of a faint star situated at an angle α from the center of the field will be a disk whose diameter is γ," etc.; for his γ is simply the maximum length of the elongated star-image, whose form, even in the spherical field, is more nearly linear than it is circular.

As to the method of derivation of my formulas I wish to say that, as the photographic plate for a symmetrical reflector must be normal to the optical axis, and also contain the focal point, it seemed to me superfluous to first deal with the blurred and distorted image in the spherical field.

The extreme simplicity of formula (4), which is derived directly by considering only intersections with the focal plane, is only rivaled by its theoretical exactness.

How greatly the defects in the images are magnified when an eccentric area of the paraboloid is used may be judged by the results for the special case which I have considered in *A.J.* 419. (For certain corrections to this last mentioned article please see *A.J.* 421.)

Lick Observatory, University of California, 1897 *Dec.* 15.

EPHEMERIS OF (247) *EUKRATE*,

By WILHELM LUTHER.

I take the liberty to send you an ephemeris of (247) *Eukrate* ($10^{M}.1$) for the opposition of 1898, calculated by my son Dr. Wilhelm Luther, in the hope that the planet may be observed at American observatories. The correction of the ephemeris will be small.

Since the oppositions in 1895 and 1896 were not observed, observations of that of 1898, when the asteroid will be in large northern declination, are very desirable.

Robert Luther.

Observatory of Düsseldorf, *Martinstrasse*, 101, 1897 *Dec.* 13.

Berlin M.T.	App. α	App. δ	log Δ	Aberr. Time
1898	h m s	° ′ ″		m s
Jan. 1	8 5 17.97	+62 32 9.1	0.148796	11 43
2	3 24.67	33 13.7	.148969	43
3	1 29.78	33 47.4	.149201	43
4	7 59 33.55	33 50.2	.149493	44
5	57 36.23	33 21.7	.149845	44
6	55 38.06	32 21.5	.150257	45
7	53 39.30	30 49.7	.150729	46
8	51 40.18	28 45.9	.151261	47
9	49 40.95	26 10.1	.151853	48
10	47 41.86	23 2.3	.152505	49
11	45 43.15	19 22.6	.153218	50
12	7 43 45.09	+62 15 11.1	0.153990	11 51
Jan. 13	7 41 47.90	+62 10 27.9	0.154822	11 53
14	39 51.80	+62 5 13.4	.155713	54
15	37 57.02	+61 59 27.9	.156664	56
16	36 3.79	53 11.7	.157674	57
17	34 12.32	46 25.3	.158742	11 59
18	32 22.82	39 9.2	.159869	12 1
19	30 35.49	31 23.9	.161053	3
20	28 50.51	23 10.0	.162294	5
21	27 8.07	14 28.2	.163591	7
22	25 28.33	+61 5 19.1	.164945	9
23	23 51.45	+60 55 43.8	.166353	12
24	22 17.54	45 42.8	.167815	14
25	20 46.75	35 17.2	.169330	17
26	19 19.18	24 27.7	.170898	19
27	17 54.91	13 15.3	.172516	22
28	16 34.05	+60 1 41.0	.174185	25
29	15 16.63	+59 49 45.6	.175903	28
30	14 2.74	37 30.2	.177669	31
31	12 52.40	24 55.7	.179481	34
Feb. 1	11 45.65	+59 12 3.0	.181339	37
2	10 42.50	+58 58 53.0	.183242	41
3	9 42.98	45 26.7	.185189	44
4	8 47.09	31 44.9	.187178	48
5	7 54.81	17 48.6	.189209	51
6	7 7 6.14	+58 3 38.7	0.191279	12 55

NEW ASTRONOMICAL WORK.

Periodic Orbits by G. H. Darwin of Cambridge. — *Acta Mathematica.* Vol. XXI, pp. 99–242.

In the motion of translation of a system of bodies if the initial positions and velocities can be so adjusted that after the lapse of a certain time the bodies retake relatively to each other the same positions and velocities, such a solution is called a periodic solution; and the orbits described may be called periodic. M. Poincaré has divided these solutions into three classes, of which the first contains those in which the periods of revolution, about one of the bodies considered as central, have not necessarily ratios of commensurability. This class might well be denominated the synodic class. In the second and third classes, on the contrary, the periods must have ratios of commensurability. In the second class the relative motions are in one plane. But in the third they are not subjected to this restriction.

Prof. Darwin has treated the first of these classes in the special case of the Problem of Three Bodies now widely known as the Restricted Problem. His numerical illustrations are confined to the particular case where the ratio of the masses of the two attracting bodies is as 10 to 1. On account of the very onerous computations necessary for the discovery of the desired orbits, the investigation has been still further limited in several directions. Nevertheless, in this memoir we have about 30 examples of periodic orbits, some of which pass in a single circuit about either one or the other of the attracting bodies, while the remainder circulate about the lighter body with one or two loops.

Prof. Darwin has not contented himself with merely tracing these orbits, but has, in addition, in nearly every case, considered the question of their stability; that is, the possibility of the superposition of small oscillations upon them without their thereby failing to satisfy the equations of motion. He has also conveniently divided the instances of instability into two classes which are denominated even and uneven.

Periodic orbits are discovered by interpolation between two or more orbits which lie close to them. For the tracing of the latter we are driven to the processes of mechanical quadratures. Prof. Darwin appears to have generally adopted that which involves the computation of the radius of curvature for points strewn along the curve, the length of the latter being the independent variable.

This memoir constitutes a remarkable contribution to celestial mechanics, as well as to the integration of differential equations. The results arrived at are always of intense interest, and sometimes afford occasion for surprise. Mathematicians and astronomers are deeply indebted to Prof. Darwin for the admirable patience he has shown in the elaboration of the subject.

G. W. H.

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THE GRAVITATIONAL CONSTANT AND THE MEAN DENSITY OF THE EARTH,

By R. S. WOODWARD.

Amongst the astronomical constants few are known with less precision than the mean density of the earth. Determinations of this constant made during the present century range from about 4 to about 7, and give an average of about 5.5. The more recent and more refined determinations fall between 5.5 and 5.6, with a tendency towards the lower of these values, but it does not appear possible at present to give precision to any narrower limits.

All known ways of deriving the mean density of the earth require measurements involving the gravitational constant. Calling this constant k, and denoting the mean density of the earth by ρ_m, it is essential to measure the values of two independent functions of k and ρ_m, whence both constants may be found by elimination. One of these functions, used hitherto in all determinations of ρ_m so far as I know, is that giving the acceleration of gravity, g, at the place of observation. The other function gives k independently of ρ_m, as in the Cavendish method, or as a function of ρ_m through g.

It is the object of this paper to give the numerical value of the product of k and ρ_m, and hence to indicate a simpler method of procedure than that usually followed in deriving ρ_m. Incidently, also, it seems proper to insist on the desirability of concentrating attention on the gravitational constant. An explanation of the meaning of this constant, and a knowledge of its precise value in terms of terrestrial units, appear to be essential to an understanding of the mechanism of gravitation itself. Quite apart therefore from the question of the mean density of the earth, the gravitational constant must be regarded, at present at any rate, as a subject of fundamental importance. If it is possible, however, to determine this constant with sufficient precision, the mean density of the earth will be known at once with a certainty indicated by four, and probably by five, significant figures, since as shown below, the product $k\rho_m$ can be computed to five such figures with an uncertainty of only one or two units in the last figure. Determinations of k made hitherto appear to be uncertain in the third significant figure. Hence, if practicable, it is very desirable that improved methods of measuring this constant be devised.

Obviously the product of the gravitational constant k and the mean density of the earth ρ_m is a constant. That is,

$$k\rho_m = C \tag{1}$$

and if C can be found, ρ_m will be known independently of the local value of the acceleration of gravity as soon as k is measured.

The constant C is found in the following manner: Let V denote the potential function due to the gravitation and rotation of the earth; let dS denote an element of the earth's surface; let ∂n be an element of the normal drawn positively inwards at dS; and denote an element of volume by $d\tau$. Writing for brevity

$$\Delta^2 V = \frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2}$$

Green's theorem gives

$$\int \Delta^2 V d\tau = -\int \frac{\partial V}{\partial n} dS$$

Calling ρ the density in the element $d\tau$, and denoting the angular velocity of rotation of the earth by ω,

$$\Delta^2 V = -4\pi k\rho + 2\omega^2$$

Substituting this in the above equation there results

$$-4\pi k \int \rho d\tau + 2\omega^2 \int d\tau = -\int \frac{\partial V}{\partial n} dS$$

Denoting the volume of the earth by v,

$$\int d\tau = v \quad \text{and} \quad \int \rho d\tau = v\rho_m$$

Hence it follows that

$$k\rho_m = \frac{\omega^2}{2\pi} + \frac{1}{4\pi v}\int \frac{\partial V}{\partial n} dS \tag{2}$$

This result it will be observed is independent of any hypothesis as to the arrangement of the earth's mass. It is known also independently of any such hypothesis that to the first order of approximation*

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* See, for example, *Die Mathematischen und Physikalischen Theorieen der Höheren Geodäsie von Dr.* F. R. Helmert, II. Teil, p. 47.

$$(3) \qquad \frac{\partial V}{\partial n} = \alpha + \beta \sin^2 q + \gamma \cos^2 q \cos 2\lambda$$

wherein α, β. γ are constants, and q, λ are the latitude and longitude respectively of dS.

Let a denote the semi-axis major and e the eccentricity of the generating ellipse of the earth's spheroid. Then the element of surface is

$$(4) \qquad dS = a^2(1-e^2)\frac{\cos q \, dq \, d\lambda}{(1-e^2\sin^2 q)^2}$$

Substituting the values (3) and (4) in equation (2) it is seen that the term in γ disappears by reason of the integration with respect to λ, which varies from 0 to 2π. Thus

$$(5) \qquad \frac{1}{4\pi v}\int \frac{\partial V}{\partial n}\, dS = \frac{\alpha S}{4\pi v} + \frac{\beta}{4\pi v}\int \sin^2 q \, dS$$

For brevity put

$$x = e \sin q$$

whence

$$\begin{aligned} x &= 0 \text{ for } q = 0 \\ &= e \text{ for } q = \frac{\pi}{2} \end{aligned}$$

Then

$$(6) \qquad \begin{aligned} S &= 2a^2 \frac{1-e^2}{e}\int_0^e \frac{dx}{(1-x^2)^2}\int_0^{2\pi} d\lambda \\ \text{and} \qquad \int \sin^2 q \, dS &= 2a^2 \frac{1-e^2}{e^3}\int_0^e \frac{dx}{(1-x^2)^2}\int_0^{2\pi} d\lambda \end{aligned}$$

Evaluating these integrals it is found that

$$\begin{aligned} S &= 2\pi a^2 \left\{ 1 + \frac{1-e^2}{2e}\log\frac{1+e}{1-e} \right\} \\ &= 4\pi a^2 (1 - \tfrac{1}{3}e^2 - \tfrac{1}{15}e^4 - \ldots) \\ &= 4\pi a^2 s_1 \text{ say;} \end{aligned}$$

and

$$\begin{aligned} \int \sin^2 q \, dS &= \pi a^2 \frac{1-e^2}{e^3}\left\{ \frac{2e}{1-e^2} + \log\frac{1-e}{1+e} \right\} \\ &= 4\pi a^2 (\tfrac{1}{3} + \tfrac{1}{15}e^2 + \tfrac{1}{35}e^4 + \ldots) \\ &= 4\pi a^2 s_2 \text{ say.} \end{aligned}$$

Substituting these values in (5), observing that

$$v = \tfrac{4}{3}\pi a^3 \sqrt{1-e^2}$$

and that $\omega = \frac{2\pi}{T}$, where T is the number of mean solar seconds in a sidereal day, equation (2) becomes

$$k\rho_m = \frac{2\pi}{T^2} + \frac{3(\alpha s_1 + \beta s_2)}{4\pi a\sqrt{1-e^2}} \qquad (7)$$

Now α and β are known from pendulum experiments, since $\frac{\partial V}{\partial n}$ is the normal acceleration at any point (q, λ) of the earth's surface. Using the values given by **Helmert** (page 241 of the work cited above),

$$\begin{aligned} \alpha &= 978.00 \text{ (centimetres) / (second)}^2 \\ \beta &= 5.19 \text{ (centimetres) / (second)}^2 \end{aligned} \qquad (8)$$

Thus all the factors in the second member of (7) are known, and hence $k\rho_m$ is known with the same precision as α, whose error is probably not greater than two units in the second decimal place.

It is worthy of remark that $k\rho_m$ is a quantity of the same kind as the square of an angular velocity, or of the same kind as an angular acceleration.

To compute the numerical value of the second member of (7) I make use of **Clarke's** spheroid of 1866. For this spheroid

$$\begin{aligned} \log (a \text{ in feet}) &= 7.320688 \\ \log e^2 &= 7.83050 - 10 \\ \log s_1 &= 9.99902 - 10 \\ \log s_2 &= 9.52346 - 10 \end{aligned}$$

With these data, with the values of α and β in equations (8), and with 1.484016 for the logarithm of the number of centimetres in a foot, it is found that the constant C in (1), or

$$k\rho_m = 36797 \times 10^{-11} \text{ / (second)}^2$$

and $\qquad \log k\rho_m = 3.56581 - 10$

OBSERVATIONS OF THE SATELLITES OF *MARS*,

By WILLIAM J. HUSSEY.

The following measures of the positions of the satellites of *Mars* were made with the 36-inch refractor, using an eyepiece magnifying 520 diameters. The angles were observed by passing the micrometer-wire through the satellite and the estimated center of the visible part of the illuminated half of the planet. The distances were measured either from the nearer limb (or terminator) or from the further limb (or terminator). During the measures the planet was kept near the center of the field of view, and its light was not cut off in any way. When the seeing was good *Phobos* did not disappear until its distance from the limb of the planet became less than 5″. Measures at distances a little greater than this were easy. *Deimos* is much fainter and more difficult to measure.

Each result given is, in general, the mean of two comparisons. In a few cases, however, the values have been obtained from a single setting of the micrometer. Such values are indicated by an asterisk following the measured quantity.

The corrections for phase and for refraction in position-angle and distance have been applied. The refractions were computed by equations (349) of **Chauvenet's** *Spherical and Practical Astronomy*, Vol. II, 5th ed. The corrections for phase were computed by the equations given in the *Astronomical Journal*, No. 337. These corrections have been applied to the position-angles, and to such of the distances as were measured from the terminator. The corrections for refraction and phase were in all cases very small.

In reducing the distances to the center of the planet, the values of its semi-diameter used were those obtained from measures made on the nights of the observations. These values are, for Dec. 20, 8″.58, and for Dec. 21, 8″.50.

From the data given by MARTH in the *Monthly Notices, R.A.S.*, April, 1896, I have computed, somewhat roughly, an ephemeris for the satellites. The column O—C gives the differences between the observed and computed places.

In the column headed Limb, N and F indicate that the measures of distance were made from the nearer and further limb (or terminator) respectively.

POSITION-ANGLES OF *Phobos*.

Mt. Hamilton M.T.				Position-Angle	O—C
	h	m	s	°	°
1896 Dec. 20	10	36	19	56.43	−1.66
		41	23	58.37	+0.64
	11	43	56	53.07	−0.14
		47	49	52.97	+0.20
21	6	11	19	236.81	−1.03
		46	6	234.36	−0.93
		50	36	233.56	−1.07
	7	17	16	229.09*	−1.72
	9	9	9	62.27	−0.02
		42	18	58.07	−1.16
		48	31	58.22	−0.55
	10	0	49	56.97	−0.89
		50	16	53.01	−0.50
		51	38	52.43	−0.90
	12	49	42	241.64	−1.82
		53	48	240.85	−2.03
	13	19	49	238.12	−2.05
		22	05	238.14	−1.84
		32	13	238.21	−0.96

POSITION-ANGLES OF *Deimos*.

Mt. Hamilton M.T.				Position-Angle	O—C
	h	m	s	°	°
1896 Dec. 20	15	47	13	57.33	+1.36
21	6	9	45	237.66	−0.52
		44	29	235.55	−1.87
		48	15	235.61	−1.84
	7	23	14	236.62	−0.13
		25	31	236.02	−0.68
	9	46	1	234.69	+1.62

DISTANCES OF *Phobos*.

Mt. Hamilton M.T.				Distance	O—C	Limb
	h	m	s	″	″	
1896 Dec. 20	10	47	1	21.80	+0.33	N
		51	31	21.55	−0.14	F
	11	2	2	21.72	+0.19	F
21	6	14	30	21.89	+0.12	F
		16	39	21.55	−0.16	N
		18	38	21.82	+0.19	N
		21	12	21.59	+0.05	F
		34	22	20.10	−0.45	F
		36	58	20.61	+0.33	N
		39	22	19.79	−0.23	F
		41	34	19.50	−0.25	N
		55	45	17.57	−0.02	N
		57	56	17.27*	+0.08	F
	7	0	24	16.70	−0.04	F
		2	43	15.98	−0.31	N
		4	38	15.67	−0.23	N
21	7	6	39	15.09	−0.40	F

Mt. Hamilton, Cal., 1897 *Dec.* 21.

DISTANCES OF *Phobos*. — Cont.

Mt. Hamilton M.T.				Distance	O—C	Limb
	h	m	s	″	″	
1896 Dec. 21	7	8	58	14.88	−0.11	N
		12	34	14.19	+0.01	F
		15	11	13.50	−0.11	N
	9	13	22	17.25	−0.54	N
		17	15	18.61	+0.18	F
		20	19	18.75	−0.16	N
		23	16	19.71	+0.37	F
	10	9	51	24.83	+0.25	N
		17	22	21.01	−0.13	F
		21	17	20.59	−0.22	N
		25	12	20.11	−0.32	F
		44	53	17.49	−0.17	N
		46	38	17.50	+0.15	F
		54	11	15.88	−0.03	F
		56	32	15.26	−0.16	N
	13	1	11	18.50	+0.14	N
		29	48	21.27	+0.12	F
		37	16	21.75	+0.17	F
		40	22	21.47*	−0.23	N
		46	28	22.00	+0.17	F
		49	4	21.51	−0.31	N
		51	58	21.57	−0.24	F
	14	8	28	21.28	+0.28	F
		14	15	20.46	−0.02	N

DISTANCES OF *Deimos*.

Mt. Hamilton M.T.				Distance	O—C	Limb
	h	m	s	″	″	
1896 Dec. 20	16	11	4	53.31*	−0.26	F
		18	57	54.24*	0.00	F
21	6	24	36	56.02	+1.50	F
		31	4	56.11	+1.62	F
	7	44	25	53.45	+1.31	F
		48	43	53.18	+1.26	N
	8	5	22	51.81	+0.93	F
		9	20	52.01	+1.43	F
		13	22	52.08	+1.76	F
		15	48	50.99	+0.86	N
		20	43	50.13	+0.36	F
		26	59	49.96	+0.69	N
		27	44	49.59	+0.37	F

It may be noted that the negative sign predominates in the residuals for the angles of both *Phobos* and *Deimos*; that the residuals for the distances of *Phobos* are generally small, with only a slight excess of the negative sign, while those for *Deimos* (except the first two) are positive and much larger than the probable error of an observation. This last circumstance led me to compare Prof. SCHAEBERLE's observations of *Deimos* of Nov. 28, 1896 (*A.J.* 399), with an ephemeris computed from the data given by MARTH. The angles agreed within the errors of observation, but of the residuals for distance fourteen are positive and four negative, the mean of the residuals for the eighteen observations being +0″48. I have made no comparisons with his other observations, nor have I examined the question whether these residuals may be explained by a revolution of the line of apsides of the satellite.

A NOTE ON AN ERROR IN THE EXPRESSION FOR THE INTENSITY OF ILLUMINATION AT THE FOCAL PLANE OF A TELESCOPE DUE TO AN INFINITELY EXTENDED LUMINOUS AREA,

By F. L. O. WADSWORTH.

In *A.J.* 421 Prof. SCHAEBERLE criticises a certain result which I have recently made use of in developing the theory of the "contrasting" or "delineating" power of telescopes. So far as the result itself is concerned, Prof. SCHAEBERLE'S criticism is perfectly just, but he has missed completely (if I understand this part of his criticism properly) the real error that was committed in obtaining it, which was detected and announced several days before Prof. SCHAEBERLE'S article reached me.* Before pointing this out, however, I desire to enter a protest against the way in which Prof. SCHAEBERLE has (no doubt quite unintentionally) misrepresented my relation to the work upon which the result in question is based.

From what Prof. SCHAEBERLE says it might be inferred, I think, that I had claimed to have discovered and announced this result for the first time. Now, I have always been careful, in discussing any subject, to give references to all previous work in the same field that was known to me at the time, and I do not desire therefore to be represented as claiming credit for anything that has been suggested or done by a previous investigator, whether the suggestion be good or bad, or the work correct or incorrect. I hope that I may be exonerated from that suspicion at least by those who read my papers carefully, and look up the references which they contain to previous work. In the particular case under discussion I gave references, both in my preliminary note to the R.A.S. (*M.N.*, June, 1897), and in the subsequent more complete paper in the *Astrophysical Journal* (Aug., 1897), to the papers of STOKES, STRUVE and RAYLEIGH.† I do not know of any others, whose work bears on this particular problem. The first two writers had dealt with it from a more purely analytical side, but RAYLEIGH, in reviewing and extending their work in his great memoir on the *Wave Theory*, to which the writer has so often referred,‡ definitely announced, then for the first time I believe, the result that the illumination at the focal plane of a telescope, due to an infinitely extended luminous area, was equal simply to πr^2, the area of the object-glass. In this memoir the writer, after reviewing the work of STOKES and STRUVE and adding an independent demonstration of his own, concludes (§ 12): "If we integrate (30)," *i.e.*,

$$d\xi \int_{-\infty}^{+\infty} I^2 \, d\eta \qquad {}^*(30)_{\mathrm{R}}$$

"with respect to ξ between the limits $-\infty$ and $+\infty$ we obtain πR^2 as has already been remarked. This represents the whole illumination over the focal plane, due to a radiant point whose image is at O.† or reciprocally the illumination at O (the same as at any other point), due to an infinitely extended luminous area." Earlier in the same memoir (§ 11) he announces the corresponding result for a luminous *line* in these words: "If the image of the line be at $\xi = 0$" (the center line in the field) "the intensity at any point ξ, η, in the diffraction-pattern may be represented by"

$$\int_{-\infty}^{+\infty} I^2 \, d\eta \qquad (8)_{\mathrm{R}}$$

and again, when dealing with the same case for a circular aperture, "If we integrate the expression $(8)_{\mathrm{R}}$ for I^2, with respect to η we shall obtain a result applicable to a linear luminous source."

I refer to these results now *more in detail* than I have heretofore, not with the intention of making them any excuse for having overlooked the error underlying their derivation, when I made use of them in developing the theory of telescopic "delineating power;" but simply because it is necessary in order to clearly point out the error that has been committed.

It will be observed that RAYLEIGH gives no proof that the integrals $(30)_{\mathrm{R}}$ and $(8)_{\mathrm{R}}$ actually represent the illumination at the focal plane due to infinitely extended sources and linear sources respectively, but *assumes* that they do, on the general principle of reciprocality or reversibility. In my own work I approached these cases from a different point of view, treating them as special cases of the more general one of a source leaving any form or extent, and either uniform or variable in intensity. For this general case I derived three expressions [(13), (16) and (17) of my paper], the last one similar in form, and only slightly changed as to notation, to that previously derived by Michelson. I applied the first of these, (13), to the determination of the correct expressions for the intensity in the images of short lines and small uniformly luminous circular areas.*

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* The error was discovered on Dec. 16. On the 17th a note announcing it was sent to the *Astrophysical Journal*, and letters giving full details as to its nature and effect on the conclusions of my previous papers were sent to Prof. SCHAEBERLE with whom I had already had some correspondence in regard to the matter, and to Prof. HALE. *A.J.* 422, containing Prof. SCHAEBERLE'S article, and the advance proof sheets of a note by Mr. NEWALL on the same subject (which will be published in the next number of the *M.N.*), reached me on the 21st, on my return to the Observatory from a temporary absence in Chicago.

† See foot notes on p. 587, *M.N.*, and pp. 120, 130, 133. *Astrophysical Journal.* In my paper in *A.N.* 3439, subsequently republished in *Knowledge*, Aug., Sept., 1897, I referred to the result simply "as resulting from the principles of the wave-theory," but in this paper I referred the reader back to the two papers just mentioned, which dealt with the problem from the historical and the purely analytical side.

‡ *Enc. Brit.*, Vol. XXIV.

* To avoid confusion I have used the subscript R to denote the number of an equation in RAYLEIGH'S memoir.

† O is the point at the center of the field.

When applied to the cases of long lines and infinitely extended areas (uniform intensity), I also *obtained correct expressions* (*i.e.*, (19) and (31) of my paper), but I too hastily assumed that these expressions (in which the variables of integration are x and y, and the field of integration extends over the *source*) were identical with the ones $(8)_R$ and $(30)_R$ (in which the variables are ξ, η, and the field of integration the focal plane), used by Rayleigh for the corresponding cases. This indeed would be the case, when the limits of integration are infinite, if the variables x, y, were *symmetrically* involved with the variables ξ, η (as at first sight they seem to be), in the expression for $I^2{}_{,}$. A more critical inspection of (14), which expresses the value of r (the variable in $I^2{}_{,}$), in terms of x, y, ξ, η, shows however that this is not the case. The first two variables are each multiplied by a factor, $\frac{f}{D}$ (which may be termed the factor of dissymmetry), and in order to obtain two new variables symmetrically involved with ξ, η, we must substitute

$$x = \frac{D}{f}\,\xi_1 \quad ; \quad y = \frac{D}{f}\,\eta_1$$

which gives us in (19) and (31) respectively,

$$(19_a) \qquad I^2{}_{{\prime\prime}} = \int_{-\infty}^{+\infty} I^2{}_{,}\, d\eta = \frac{D}{f}\int_{-\infty}^{+\infty} I^2{}_{,}\, d\eta_1 = \frac{D}{f}\,(Z_{{\prime\prime}})$$

and (31_a)

$$I^2{}_{,,,} = \int_{-\infty}^{+\infty} dx \int_{-\infty}^{+\infty} I^2{}_{,}\, dy = \frac{D^2}{f^2}\int_{-\infty}^{+\infty} d\xi_1 \int_{-\infty}^{+\infty} I^2{}_{,}\, d\eta_1 = \frac{D^2}{f^2}\,(Z_{,,,})$$

and the integrals $(Z_{{\prime\prime}})$ and $(Z_{,,,})$ are now respectively equal to the integrals $(8)_R$ and $(30)_R$ of Lord Rayleigh.

The integrals themselves were correctly evaluated in my former paper. This is the point at which Prof. Schaeberle falls into error. His criticism of this part of the work is peculiar and difficult to understand. As near as I can make out he seems to think that in the integration $I^2{}_{,}$ was regarded as constant and independent of f. If he had only taken the trouble to refer back to equations (3) and (14) which express $I^2{}_{,}$ as a function of the various quantities involved, he would have immediately discovered that it varies not only with x, y, ξ and η, the variables of integration (in the two cases), but also (as he insists it ought to do), as $\frac{1}{f^2}$ (not *nearly*, but *exactly*). But in the process of integration an f^2 is introduced in the numerator which cancels the f^2 in the denominator.

To recapitulate briefly; the real error which was committed in Lord Rayleigh's case was in assuming the principle of the reversibility of images, *i.e.*, in assuming

$$\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} I^2{}_{,}\, dx\, dy = \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} I^2{}_{,}\, d\xi\, d\eta$$

which as now appears is only true when D, the distance of the source, is equal to f, the focal length of the image-forming lens; in my own case the error was a more purely analytical (and therefore less excusable) one, resulting from my overlooking the factor $\left(\frac{D}{f}\right)^2$ which it becomes necessary to introduce in order to effect the transformation of variables. There is no excuse for my having been guilty of a blunder of this nature, which, now that it has been pointed out, seems so perfectly obvious. I may perhaps say, however, that it might have been detected earlier had it not been for the fact that the result first obtained explained so perfectly and completely the practical observations of Prof. Barnard as to the relative photographic efficiency of lenses of small and large aperture (or more strictly long and short focal lengths), for which no explanation had, so far as the writer is aware, previously been offered. If "the best test of theory is its ability to explain observed facts," then the remarkable agreement between the actual times of exposure required to obtain a given photographic result with different lenses, and the computed times as determined by the theory of contrast,* must be regarded as a strong confirmation of the correctness of the theory and in turn of the results on which it is based. This confirmation, coupled with the confidence inspired by Rayleigh's name, and the fact that none of those who raised the question as to the accuracy of one of the fundamental results (that for the general illumination of the focal field by the light from the sky), were able to point out any flaw in the reasoning or in the mathematical processes by which it was obtained, was at any rate sufficient to convince me for the time being of the correctness of my work. And it was only after I had more fully investigated the influence of a certain factor (which for obvious reasons was not considered in the preliminary development of the theory of contrast), and found that, although it had only a secondary importance in visual work, it introduced in photographic work another term of the form $\frac{1}{f^2}$ in the expressions for contrast (thus making the relative photographic efficiency of different lenses apparently vary in the case of nebular photography, for example, as $\frac{1}{f^4}$ instead of $\frac{1}{f^2}$ as actually found in practice), that I was led to suspect an error in Rayleigh's value for the focal plane illumination, and to discover, on a reinvestigation of the problem the error now pointed out.

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* These results were used in the application of the theory of contrasting or "delineating power" to the case of linear markings on planetary surfaces which was treated, from the point of view of visual observations, in *A.J.* 414; and, from a photographic point of view, in the *Observatory* for Aug., Sept. and Oct., pp. 333, 365, 404.

* See *A.N.* 3439, 100, and *Knowledge*, August, 1897, p. 194.

The effect referred to is that due to atmospheric aberration. It had not by any means been overlooked, and had indeed been already taken into account in investigating the conditions of efficiency of the spectroscope and spectrograph; in which cases, however, it is of no importance whatever except in that of the objective-spectroscope, where it was fully considered.* It is likewise, as already intimated, of secondary importance in the case of visual observations, or in photographic work in which the exposures are either very short (*i.e.*, "instantaneous") or are made by the "intermittent method" recently proposed by the writer; its principal effect in such cases being to reduce the available time of "good seeing," or to limit the aperture of the telescope that can be used most efficiently. Hence the expressions given in my former paper† for the contrast between the general focal field and sources of various forms. Cases A, B and C require to be modified by multiplying by a factor, f^2 (the correct expression for the focal plane intensity being $\frac{\pi b^2}{4f^2}$ instead of $\frac{\pi b^2}{4}$ as first used), when we are considering the *visual delineating power* (or as just noted the photographic delineating power for the equivalent cases of "instantaneous" and "intermittent" exposure). No such cases have yet been considered. The expressions for the intensity of the images of short lines and surfaces of limited area, were, as already stated, correctly derived, and the expressions for the "contrast" between such surfaces when superposed, and for the "delineating power" of the telescope used in viewing or photographing them (by the proposed intermittent method) are therefore also correct.‡

The expressions for the "contrast" between image and focal field in cases of A, B_2, and C, *when prolonged photographic exposures are in question, are correct as they stand in my former paper.* For the error introduced by the omission of the factor $\frac{1}{f^2}$ in the expression for the focal plane illumination due to the sky, is corrected by the omission of the corresponding factor $\frac{h}{f^2}$ representing the effect of atmospheric aberration on the intensity of the photographic image.* The conclusions based upon these results with regard to the relative *photographic efficiency*, *i.e.*, *photographic delineating power* of different objectives for nebular and stellar spectrographic work, and for the portraiture of stars, star clusters, nebulas, and coronal phenomena (during and without an eclipse), which were reached in my papers in the *Monthly Notices, R.A.S.*, June, 1897, pp. 588, 589, and in *A.N.* 3439, 108, 109, 110, are therefore entirely correct. One of the minor conclusions (*not* included in the summaries just alluded to) of the latter paper in regard to the fogging of the photographic plate by the effect of the sky-illumination is, however, in error, the intensity of this effect varying as the square of the *angular aperture* instead of as the square of the *linear aperture* as there stated.

Supplementary Note. As already stated in a foot-note at the beginning of this paper, I have just received advance proof sheets of a note by Mr. NEWALL which will appear in the next number of the *Monthly Notices*. Mr. NEWALL ascribes the error in the result for the focal plane illumination to another quite different cause from that suggested by Prof. SCHAEBERLE, the only point of resemblance between their criticisms being that both are correct in objecting to the result, and both at fault as to the real error committed in obtaining it. Mr. NEWALL's note also raises some points that are best dealt with in a separate communication to the R.A.S.

Yerkes Observatory, 1897 *Dec.* 22.

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[*] "The Objective Spectroscope," *Astrophysical Journal*, June, 1896, pp. 61–64.

[†] *Astrophysical Journal*, August, 1897, pp. 134, 135.

[‡] See papers "On the Effect of the Size of an Objective on the Visibility of Linear Markings on the Planets," *A.J.* 414; and "On the Photography of Planetary Surfaces," *Observatory*, Vol. XX, pp. 303, 365, 404. It was the consideration of the effect of aberration in these cases (where it is of secondary importance as already indicated), that first directed my attention to the importance it might assume in those cases in which the photographic exposure was continuous and prolonged. But my attention was temporarily distracted from the further prosecution of the inquiry, first by the pressure of work incident to the preparation for the dedication of the Observatory, and then by that attending the determination of the color-curve of the large objective, the computing of correcting lenses for the same, and the other work of preparing the instruments for the beginning of spectroscopic research. I was therefore only able to take it up again a few days ago.

[*] Atmospheric aberration produces of course no effect in the intensity of the general focal plane illumination. The nature and magnitude of its effect on the images of pointed lines and small finite areas is taken up more at length in Part II of my paper, on the General Theory of Telescopic Images, which appears in the January number of the *Astrophysical Journal*, and to which the reader is referred for further information.

NEW ASTEROIDS.

Prof. KREUTZ communicates the discovery of three new asteroids by CHARLOIS, as follows:

		Nice M.T.				
DM	12^M	1897 Dec. 18 $9^h\ 29^m.0$	$\alpha = 4^h\ 42^m\ 1^s$,	$\delta = +18^\circ\ 0'$.	Daily motion -18^s	and $10'$ southward.
DN	12.8	Dec. 18 9 29.0	4 47 0,	+20 11.	" " -48	" 1 "
DO	12	Dec. 18 9 29.0	4 53 28,	+19 21.	" " -56	" 0 "

COMET a 1898 = WINNECKE'S PERIODIC COMET.*

A telegram from Prof. SCHAEBERLE announces the rediscovery of this comet by PERRINE in the position,

1898 Jan. 2.0873 Gr. M.T. $\alpha = 15^h\ 19^m\ 2^s.5$; $\delta = -3°\ 58'\ 34''$.

Thus the correction to HILLEBRAND's ephemeris, *A.J.* 417, is $\Delta\alpha = +2^m\ 8^s$, $\Delta\delta = -9'.3$. Applying this correction to the extension of HILLEBRAND's ephemeris, *A.N.* 3447, we have the following approximately corrected ephemeris:

Berlin M.T.	α	δ	Berlin M.T.	α	δ
	h m s	° ′		h m s	° ′
1898 Jan. 6.5	15 35 1	−5 1.6	1898 Jan. 18.5	16 22 8	−7 51.4
10.5	15 50 6	−5 58.6	22.5	16 39 7	−8 46.3
14.5	16 5 48	−6 55.4	26.5	16 56 44	−9 39.6

which will serve until a better one can be supplied. — ED.

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* *From Supplement to* No. 423. A new ephemeris will be found immediately following.

EPHEMERIS OF WINNECKE'S COMET = a 1898.

PERRINE's observations below have been used to correct the time of perihelion passage, using VON HAERDTL's elements. We find

$$\Delta T = -0.00786\,\Delta\alpha\cos\delta \quad\text{and}\quad +0.00109\,\Delta\delta,$$

where $\Delta\alpha$ and $\Delta\delta$ are expressed in seconds of time and are, respectively. Thus we get $T = 1898$ Mar. 20.392 Gr. M.T., and this and the other elements given below represent PERRINE's observations in both coordinates within the error of observation; O−C being $-0^s.06$ and $-0''.2$.

ELEMENTS.

T = 1898 Mar. 20.392 Gr. M.T.

$$\left.\begin{aligned} \omega &= 173°\ 21'\ 10''.0 \\ \Omega &= 100\ \ 51\ \ 45.5 \\ i &= 16\ \ 59\ \ 34.0 \end{aligned}\right\}\ 1898.0$$

$\log e = 9.854161$

$\log a = 0.510521$

EPHEMERIS FOR GREENWICH MIDNIGHT.

1898	App. α	App. δ	log Δ
	h m s	° ′ ″	
Jan. 14.5	16 6 4.98	− 6 55 24.5	0.2015
16.5	14 13.20	7 23 30.1	
18.5	22 30.95	7 51 21.0	0.1912
20.5	30 58.35	8 18 53.7	
22.5	39 35.37	8 46 4.4	0.1802
24.5	48 21.97	9 12 49.2	
26.5	16 57 18.02	9 39 3.5	0.1701
28.5	17 6 23.42	10 4 42.6	
30.5	15 38.03	10 29 41.8	0.1608
Feb. 1.5	25 1.63	10 53 56.4	
3.5	34 33.95	11 17 21.0	0.1527
5.5	44 14.66	11 39 50.2	
7.5	17 54 3.34	−12 1 18.5	0.1457

ED.

OBSERVATIONS OF WINNECKE'S COMET = a 1898,

MADE WITH THE 36-INCH EQUATORIAL OF THE LICK OBSERVATORY, UNIVERSITY OF CALIFORNIA,

BY C. D. PERRINE.

1898 Mt. Hamilton M.T.	*	No. Comp.	☄ − *		☄'s apparent		log pΔ	
			Δα	Δδ	α	δ	for α	for δ
h m s			m s	′ ″	h m s	° ′ ″		
Jan. 1 17 4 44	1	d 2	−0 1.75	. . .	15 18 53.97	. . . .	n9.573	. .
1 17 56 16	1	3	. . .	+0 33.7	. . . .	−3 58 32.6	. .	0.757
1 17 59 7	1	d 3	+0 6.79	. . .	15 19 2.51	. . . .	n9.462	. .
2 16 29 11	2	d 3	−0 12.94	. . .	15 22 22.99	. . . .	n9.612	. .
2 16 35 29	2	2	. . .	+0 19.2	. . . .	−4 12 4.5	. .	0.747
2 16 54 15	2	d10 , 8	−0 9.58	+0 11.5	15 22 26.35	−4 12 12.2	n9.585	0.750
3 17 29 44	4	d10 , 8	−0 6.10	−0 10.4	15 26 8.82	−4 26 51.8	n9.522	0.757

Mean Places for 1898.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	15 18 55.59	+0.13	−3 58 58.6	−7.7	Munich (2) 5704
2	15 22 35.79	+0.14	−4 12 16.0	−7.7	Micrometer-comparison with *3
3	15 23 47.57	+0.14	−4 14 59.7	−7.6	Weisse's Bessel 397
4	15 26 14.76	+0.16	−4 26 33.7	−7.7	Micrometer-comparison with *5
5	15 25 37.86	+0.16	−4 26 28.6	−7.7	Weisse's Bessel 426

d indicates that $\Delta\alpha$ was measured directly with the micrometer.
The comet is very faint, about 10″ to 15″ diameter, with a slight brightening at the center.

ANDERSON'S NEW VARIABLE IN *COMA BERENICES**,

$12^h\ 23^m\ 1^s.0$, $+32°\ 18'\ 19''$ (1855) : $12^h\ 25^m\ 15^s.2$, $+32°\ 3'\ 22''$ (1900),

BY J. A. PARKHURST.

ANDERSON announced this star in *A.N.* 3433. I have the following observations which seem to confirm its variability:

		M		M
1897 Aug.	1	10.7	Aug. 27	11.5
	3	10.8	29	11.6
	6	10.7	Sept. 3	11.7
	11	11.1	12	<11
	13	11.1	14	11.8
	14	11.2	Oct. 8	<11
	19	11.4	25	11.2
	20	11.3	Dec. 31	9.5
	24	11.4		

The magnitudes are only approximate, and depend chiefly on my comparison-stars *e* and *c*, which have the following magnitudes and coordinates from the variable:

e $+60^s.5$ $-12'.2$ $10^M.0$ c $+9^s.9$ $+4'.5$ $11^M.5$

The position of the variable was given in *A.J.* 412; and a small chart with the coordinates of the comparison-stars will be found in *Popular Astronomy* for Sept., 1897, p. 270.

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* In consequence of this confirmation by PARKHURST the definitive notation, 4471 *T Canum Venaticorum*, is herewith assigned to this star, which distinctly lies within the constellation *Canes Venatici*, and not in *Coma Berenices*, to which it has hitherto been ascribed.
ED.

MEASURES OF *SIRIUS*, *PROCYON*, AND β 395,

BY R. G. AITKEN.

The following measures were made with the 36-inch telescope of this observatory. For *Sirius* and *Procyon* a power of 520 was used; for β 395 a power of 1500; and all the measures were made under excellent conditions. Passing clouds prevented a measure of distance of the companion of *Sirius* on the last night.

Sirius.

Date	Position Angle	Distance	Weight
	°	″	
1897.731	175.9	3.92	10
.756	174.4	4.04	5
.838	175.8	4.14	10
.915	172.8	. . .	10
1897.81	174.7	4.03	

Procyon.

Date	Position Angle	Distance	Weight
	°	″	
1897.838	321.7	4.84	10
.876	324.8	4.67	10
.915	324.8	4.59	10
1897.88	323.8	4.70	

β 395.

Date	Position Angle	Distance	Weight
	°	″	
1897.909	273.1	0.25	8
.912	273.6	0.25	10
.932	274.4	0.30	10
1897.92	273.7	0.27	

Lick Observatory, University of California, 1897 *Dec.* 31.

THE ASTRONOMICAL JOURNAL.

Referring to the notice on p. 8 (*A.J.* 409) the Editor regrets to announce the still further depletion of the stock of available copies of Volume I, which is no longer obtainable complete; but incomplete copies can still be furnished as follows, *if promptly ordered*: Four numbers missing (nos. 1, 4, 5 and 6), at \$9.00; five numbers missing (nos. 1, 3, 4, 5 and 6), at \$7.50; six numbers missing (nos. 1, 2, 3, 4, 5 and 6), at \$6.00.

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THE TWO-METHOD PERSONAL EQUATIONS OF THE GREENWICH OBSERVERS,

By TRUMAN HENRY SAFFORD.

The tables which follow contain the results of an investigation carried on at Greenwich since 1885 up to 1894, the last year when results are published.

By e I denote the ordinary chronographic personal equation as computed from year to year, by e' the eye-and-ear personal equation for the observers who were in charge of the transit circle. Both e' and e are referred to the chronographic registration of a standard observer, Mr. DOWNING from 1885 to 1891 inclusive, and Mr. LEWIS since. For 1891 Mr. DOWNING served as standard observer for the eye-and-ear personal equation only, and Mr. LEWIS for the chronographic. When e or e' is positive the observer anticipates the standard observer. The quantity $e'-e$ then will be (when positive) the amount of time by which each observer anticipates his own chronographic transits.

After forming the table of $e'-e$ the mean value of this quantity was taken for the ten years, giving each observer for the year equal weight. The results of this process are as follows:

Year	No. of Obs.	Mean $e'-e$	Year	No. of Obs.	Mean $e'-e$
1885	5	$+0^{s}.158$	1890	9	$+0^{s}.163$
1886	5	+0.174	1891	5	+0.122
1887	5	+0.170	1892	10	+0.165
1888	5	+0.212	1893	15	+0.125
1889	5	+0.162	1894	10	+0.162

The five observers, H. T., A. D., T., L., and H., are the only ones tested in 1885 to 1889 inclusive, and in 1891. They are very skilful and experienced. In 1890, and 1892 to 1894 inclusive, a number of the "computers" are so tested together with some younger assistants. It is difficult to make a distinction between the two classes of assistants and "computers" which shall not quite possibly place men of equal experience as observers in two different classes. But it seems to me perfectly safe to find the mean values of $e'-e$ for the computers separately. This I have done for the four years as follows:

Year	No. of Computers	Mean $e'-e$ for Computers
1890	5	$+0^{s}.121$
1892	5	+0.064
1893	9	+0.083
1894	6	+0.132

The general mean of the ten years, giving each year equal weight, is $+0^{s}.161$, including all the observers, and the same for the four years in which computers are included is $+0^{s}.101$ for computers only. On the other side the mean for 1885 to 1889 and 1891 is $+0^{s}.166$ for the five assistants, H. T., A. D., T., L., and H.; and this quantity is so much larger than the mean $e'-e$ for computers for any one of the four years in which computers were tested, that there can be little doubt that the difference represents a real quantity. In other words, for the five experienced observers the mean $e'-e$ is $0^{s}.065$ greater than for the seven computers. If we take the ten separate yearly means for all as quantities varying by accidental causes and subject to GAUSS's law of errors, we find the mean error of a single year to be $\pm 0^{s}.025$, and of the ten years $\pm 0^{s}.008$. The probable error would be $\pm 0^{s}.017$ for one year, calculated by $0.6745 \times$ mean error, and $\pm 0^{s}.014$ calculated by the sum of discrepancies from $0^{s}.161$; or $\pm 0^{s}.005$ for the ten years.

I have elsewhere given reasons for thinking that the quantity $0^{s}.162 \pm 0^{s}.005$, by which an average observer at Greenwich anticipates his own chronographic times of transit, indicates that the observers' personal equations are due to psychical causes, and that this calculation confirms WUNDT's theory of personal equation by the two methods. The principal factor in the eye-and-ear personal equation is "*Zeitverschiebung*," or "displacement of time" when the observer attempts to fix the place of the star at the beats. No sufficient reason has been yet shown why this displacement should vary with the magnitude of the star in a way different from that which ARGELANDER experienced; namely, a reversal in sign of the displacement when the star is so faint that its observation causes difficulty in following it from second to second. Hence the evidence in favor of a "*Helligkeitsgleichung*" for the eye-and-ear method is more or less conflicting in different cases, and not readily summarized without more details than are yet available. Again, for stars bright enough to be readily observed, it seems likely that such *Helligkeitsgleichung* can be reduced to a very small amount, as at Pulkowa in ROMBERG's observations. But on the other hand the evidence for the variation with magnitude in chronographic registration is much more consistent and uniform, and is confirmed by the similar influence found by psychologists on the time of reaction to a faint impression on the senses, a delay due to the faintness. The general conclusion as to the eye-and-ear method which can be derived from the yearly means of $e'-e$ is that, on the whole, it produces times of transit which, for the average observer of sufficient experience, are within a very few hundredths of a second of the truth; but that the chronographic method furnishes similar times which are too late on the average by the reaction-time, rather more than a tenth of a second. I must defer to another occasion the results of some studies which I have made into the eye-and-ear personal equation as obtained by the observations of 1794 to 1859 at various observatories; studies which have produced approximate results, but are still incomplete.

The two-method equations for A. D. and L., as given above, indicate that both astronomers observed by eye-and-ear with very little constant error. The mean $e'-e$ for A. D. is $0^s.123$ for seven years, 1885–1891, and for L. $0^s.143$ for nine years, 1885–1891 and 1892–3; or for the mean of the two $0^s.133$, agreeing nearly with what we may suppose is the normal amount. For both standard observers the two-method equation is less than the general average, and more than it is for the average computer.

The values of e, the chronographic personal equation referred to the standard observer, show in some cases a considerable negative value. In one of these cases the observer employs Method B (see *A.J.* 369); and, if the process of the other observers who exhibit these negative values is capable of psychological identification with that of H., a point would be gained in the theory of personal equation generally.

Williams College Observatory, 1898 *Jan.* 6.

Obs.	e	e'	$e'-e$
Year 1885.			
	s	s	s
H. T.	+0.15	+0.11	–0.04
A. D.	0.00	+0.06	+0.06
T.	+0.10	+0.19	+0.09
L.	+0.02	+0.08	+0.06
H.	–0.23	+0.39	+0.62
Year 1886.			
H. T.	+0.15	+0.20	+0.05
A. D.	0.00	+0.08	+0.08
T.	+0.13	+0.15	+0.02
L.	+0.01	+0.14	+0.13
H.	–0.23	+0.36	+0.59
Year 1887.			
H. T.	+0.12	+0.16	+0.04
A. D.	0.00	+0.07	+0.07
T.	+0.12	+0.15	+0.03
L.	+0.03	+0.16	+0.13
H.	–0.22	+0.36	+0.58
Year 1888.			
H. T.	+0.08	+0.12	+0.04
A. D.	0.00	+0.20	+0.20
T.	+0.16	+0.25	+0.09
L.	+0.05	+0.24	+0.19
H.	–0.22	+0.32	+0.54
Year 1889.			
H. T.	+0.09	+0.17	+0.08
A. D.	0.00	+0.12	+0.12
T.	+0.11	+0.07	–0.04
L.	+0.05	+0.20	+0.15
H.	–0.21	+0.29	+0.50
Year 1890.			
H. T.	+0.03	+0.07	+0.04
A. D.	0.00	+0.15	+0.15
L.	+0.07	+0.22	+0.15
H.	–0.20	+0.31	+0.51
S. D.	+0.11	+0.02	–0.09
A. C.	+0.04	+0.35	+0.31
W. R.	–0.04	+0.08	+0.12
H. F.	–0.01	+0.16	+0.17
A. M.	0.00	+0.11	+0.11

Obs.	e	e'	$e'-e$
Year 1891.			
	s	s	s
H. T.	+0.09	+0.09	0.00
A. D.	0.00	+0.18	+0.18
T.	+0.15	+0.09	–0.06
L.	+0.10	+0.19	+0.09
H.	–0.14	+0.26	+0.40
Year 1892.			
L.	0.00	+0.19	+0.19
H.	–0.21	+0.27	+0.48
A. C.*	+0.02	+0.22	+0.20
B.	+0.12	+0.19	+0.07
T. H.	–0.04	+0.35	+0.39
S. D.	+0.01	+0.13	+0.12
H. F.	–0.13	+0.01	+0.14
C. M.	+0.07	+0.11	+0.04
C. D.	–0.02	+0.04	+0.06
D. E.	+0.13	+0.09	–0.04
Year 1893.			
H. T.	+0.01	+0.19	+0.18
L.	0.00	+0.20	+0.20
H.	–0.20	+0.21	+0.41
A. C.*	–0.02	+0.08	+0.10
B.	+0.07	+0.06	–0.01
T. H.	–0.14	+0.08	+0.22
H. F.	–0.18	+0.02	+0.20
A. M.	–0.09	0.00	+0.09
C. M.	0.00	+0.06	+0.06
C. D.	–0.01	+0.05	+0.09
R. C.	–0.03	+0.06	+0.09
D. E.	+0.05	+0.18	+0.13
W. B.	+0.12	+0.16	+0.04
J.	+0.01	+0.09	+0.08
O. T.	0.00	–0.03	–0.03
Year 1894.			
D.	+0.01	+0.22	+0.21
H.	–0.23	+0.21	+0.47
A. C.*	–0.03	+0.06	+0.09
B.	0.00	+0.06	+0.06
H. F.	–0.19	+0.03	+0.22
C. D.	–0.07	+0.05	+0.12
D. E.	–0.02	+0.10	+0.12
W. B.	+0.05	+0.11	+0.06
J.	+0.05	+0.28	+0.23
O. T.	–0.04	0.00	+0.04

The assistants are H.T., A.D., T., L., H., A.C., of 1892, 1893, and 1894, T.H., B., D., but in 1890 the initials A.C. stand for another, COCHRANE, a computer; the assistant A.C.* is CROMMELIN; the other initials denote computers.

NOTES ON VARIABLE STARS, — No. 22,

BY HENRY M. PARKHURST.

Intermediate Caps. In observing with the full aperture (*A.J.* 326 and 333), the standards, observed with the logarithmic cap, were necessarily so bright as to reduce the aperture to a rapidly converging segment. In 1897 November I constructed an intermediate cap, with which can be observed stars fainter than with the logarithmic cap, making the standards for the full aperture observable before the occulting line has passed beyond the center of the circle; thus increasing the number observed with a nearly uniform diminution, and increasing the accuracy of the standard for the remaining stars. The intermediate cap exposes at the left a segment .75-inch deep, at the right a segment 2.1 inches deep; and the bounding lines of the intermediate section are straight lines. The table for reduction shows, for two-thirds of the aperture comprised between these straight lines, a scale approximately uniform. A second intermediate cap, with the same initial and final segments, reduces the width at the final line to one inch; and with this cap the same uniformity of scale is continued throughout.

T Sagittarii. The periods suggested in *A.J.* 365 and 393, for the purpose of explaining the maxima taken as epochs in the First and Second Catalogues, are contradicted, and the period of 384 days confirmed. Dividing by two, making the epoch 2402864, the period 191.3 days (making $M-m = 58$ days), harmonizes all these observations, except those in *A.J.* 393, and the principal maximum of this year, which remain unaccounted for.

RESULTS OF OBSERVATIONS.

No.	Star	Phase	Observed Date Julian	 Calendar	E	Corr.	W	Mag.	Factors			Remarks
				1897								
6888	*RW Sagittarii*	Max.	4170	Sept. 2	–	–	8P	9.8	1.8	2.2	65^{d}	Accidentally omitted, *A.J.* 421
6892	*RX Sagittarii*	Max.	4100	June	–	–	2P	–	–	–	–	" " " "
6903	*T Sagittarii*	Max. A	4152	Aug. 15	2	0	5	8.5	–	–	–	See note above
"	"	Max. B	4175	Sept. 7	2	+23	9	7.86	0.24	0.27	9	
6905	*R Sagittarii*	Max.	4088	June 12	42	– 8	3	7.4	–	–	–	Agrees with previous years
6921	*S Sagittarii*	Max.	4164	Aug. 27	49	– 5	8	10.31	0.14	0.25	6	
6940	*U Lyrae*	–	–	–	–	–	–	–	–	–	–	See note below
7118	*X Aquilae*	Max.	4077	June 1	4	– 5	1	–	–	–	–	Secondary max. two weeks later
7139	*RR Sagittarii*	Min.	3890	Nov. 26	6	–	E	–	–	–	–	1896
"	"	Min.	4228	Oct. 30	7	–	E	–	–	–	–	1897
7155	*RR Aquilae*	Max.	4109	July 3	2	–73	7	10.27	0.36	0.84	23	Period 367 days?
7162	*RS Aquilae*	Max.	4185	Sept. 17	–	–	9	9.88	0.72	0.59	15	Tends to confirm per., *A.J.* 393
7234	*R Capricorni*	Max.	4165	Aug. 28	40	–25	2	11.4	–	–	–	Possibly earlier
7240	*RY Cygni*	–	–	–	–	–	–	–	–	–	–	See note below
7242	*S Aquilae*	Max.	4193	Sept. 25	79	+51	8	9.22	0.77	0.73	27	
"	"	Min.	4257	Nov. 28	80	+40	9	10.91	0.96	0.86	33	
7252	*W Capricorni*	Max.	4149	Aug. 12	44	+23	9	11.38	0.35	0.42	16	See note below
7260	*Z Aquilae*	Min.	4089	June 13	8	–	E	12.5]	–	–	–	Adopting time from *A.J.* 393
"	"	Max.	4147.4	Aug. 10	8	–10	9	9.79	0.36	0.70	14	Interval seems 130 days
"	"	Max.	4150	Aug. 13	8	– 7	6P	9.8	–	–	–	
"	"	Min.	4212	Oct. 14	9	– 7	5	13.6	0.75	0.67	83	Not seen for 50 days
7261	*R Delphini*	Max.	4047.3	Aug. 10	41	–33	9	8.05	0.25	0.25	6	Corr. diminishing again
7351	*RW Cygni*	–	–	–	–	–	–	–	–	–	–	Changes slow and slight
7404	*R Microscop.*	Min.	3863	Oct. 30	3	–	E	–	–	–	–	1896
"	"	Max.	4215	Oct. 17	5	+11	9	9.18	0.60	0.61	22	1897
7431	*S Delphini*	Max.	4276	Dec. 17	42	0	9	9.81	1.60	1.04	24	
7435	*Y Aquarii*	Min.	4240:	Nov.	–	–	–	13]	–	–	–	Fluctuation
7448	*W Aquarii*	Min.	3793:	Aug. 21	8	–	E	–	–	–	–	Invisible five months 1896
"	"	Max.	3973	Feb. 17	8	–	E	–	–	–	–	Prob. more than 30 days late
7450	*V Aquarii*	Max.	4160	Aug. 23	10	–	E	–	–	–	–	No appreciable change
7455	*U Capricorni*	Max.	4133	July 27	72	– 1	3	10.69	–	0.42	–	See note below
7456	*RR Cygni*	Max.	4231	Nov. 2	21	–	E	9.00	–	–	–	Uncertain fluctuation

INDIVIDUAL OBSERVATIONS.

Including Observations by ARTHUR C PERRY.

6888 *RW Sagittarii.*

(Continued from 421.)

Julian	Calendar	Mag.
	1897	
4102.7	June 26	10.1P
4115.6	July 9	10.1P
4128.7	22	9.8P
4140.6	Aug. 3	10.1P
4157.6	20	9.8P
4165.6	28	9.7P
4172.6	Sept. 4	9.7P
4215.5	Oct. 17	10.1P
4224.5	26	10.1P

6892 *RX Sagittarii.*

(Continued from 421.)

Julian	Calendar	Mag.
	1897	
4102 7	June 26	9.8P
4115.6	July 9	9.8P
4128.6	22	10.4P
4140.6	Aug. 3	11.1P
4142.6	5	11.4P
4157.6	20	11.8P
4165.6	28	12.0P
4172.6	Sept. 4 to	
4224.5	Oct. 26	12.]P
	3 dates	

6903 *T Sagittarii.*

(Continued from 393.)

Julian	Calendar	Mag.
	1897	
4078.7	June 2	11.8
4101.6	25	10.6
4128.7	July 22	9.9P
4137.6	31	9.55_2
4140.7	Aug. 3	9.5P
4142.6	5	9.4P
4150.6	13	8.56_2
4157.5	20	8.69_2
4157.6	20	8.8P
4159.5	22	8.92_2

6903 *T Sagitt.*—cont.

Julian	Calendar	Mag.
	1897	
4161.6	Aug. 24	8.7P
4165.6	28	8.5P
4168.5	31	8.36_2
4169.6	Sept. 1	8.46_2
4170.5	2	8.12_2
4171.6	3	8.29_2
4172.6	4	7.72_2
4172.6	4	8.5P
4177.6	9	7.85
4178.5	10	8.01_2
4182.5	14	8.38_2

6903 *T Sagitt.*—cont.

Julian	Calendar	Mag.
	1897	
4183.5	Sept. 15	8.07
4186.5	18	7.89_2
4189.5	21	8.31_2
4193.5	25	8.24_2
4195.5	27	8.69_2
4215.5	Oct. 17	8.3P
4224.5	26	8.7P

6905 *R Sagittarii.*

(Continued from 393.)

Julian	Calendar	Mag.
	1897	
4078.7	June 2	8.2

6905 *R Sagitt.*—cont.

Julian	Calendar	Mag.
	1897	
4090.7	June 11	7.4
4091.7	18	7.8
4102.7	26	7.4r
4115.6	July 9	8.0r
4128.7	22	8.4r
4140.7	Aug. 3	8.8r

6921 *S Sagittarii.*

(Continued from 365.)

Julian	Calendar	Mag.
	1897	
4161.6	Aug. 24	9.9
4162.6	25	10.41$_2$
4165.6	28	9.88$_2$
4166.5	29	10.59$_2$
4167.6	30	10.46$_2$
4168.5	31	10.40$_2$
4170.5	Sept. 2	10.52$_2$
4171.6	3	10.69$_2$

6940 *V Lyrae.*

Julian	Calendar	Mag.
	1894	
3159.5	Nov. 26	10.7 :
3178.5	Dec. 15	10.7 :
3188.5	25	10.5
3194.5	31	10.4
	1895	
3195.5	Jan. 1	10.5
3327.6	May 13	10.5
3419.6	Aug. 13	10.3
3451.6	Sept. 14	10.2
3484.5	Oct. 17	10.2
3510.5	Nov. 12	10.8
3513.5	15	10.70$_2$
3519.5	21	10.75$_2$
3520.5	22	10.79
3539.5	Dec. 11	11.2
3543.5	15	10.69$_2$
	1896	
3712.7	June 1	11.4
3742.6	July 1	11.3
3858.5	Oct. 25	10.0
3859.5	26	10.88$_2$
3867.5	Nov. 3	10.60$_2$
3925.5	Dec. 31	10.97$_2$
	1897	
4106.6	June 30	10.24$_2$
4165.5	Aug. 28	10.59$_2$
4211.6	Oct. 13	10.40$_2$
4282.5	Dec. 23	10.34$_2$

7118 *X Aquilae.*

Cont. from 393. Comp. Stars 339

Julian	Calendar	Mag.
	1897	
4077.7	June 1	8.94$_2$
4078.6	2	9.28$_2$
4087.6	11	9.83$_2$
4090.6	14	9.23$_2$
4091.6	15	9.18$_2$
4098.6	22	9.78$_2$
4102.6	26	9.95$_2$

7139 *RR Sagittarii.*

Julian	Calendar	Mag.
	1896	
3811.6	Sept. 11	10.5
3833.6	30	10.7

7139 *RR Sagitt.*—cont.

Julian	Calendar	Mag.
	1897	
4170.6	Sept. 2	10.4
4186.6	18	11.0
4193.5	25	11.4
4215.5	Oct. 17	11.6
4224.5	26	11.57$_2$
4241.5	Nov. 12	11]

7155 *RR Aquilae.*

Cont from 393. Comp. Stars 393.

Julian	Calendar	Mag.
	1897	
4077.7	June 1	12.3
4087.7	11	11.6
4094.7	18	10.7
4099.7	23	10.2
4102.6	26	10.94$_2$
4103.6	27	10.26$_2$
4108.6	July 2	10.32$_2$
4111.6	5	10.25$_2$
4115.6	9	10.36$_2$
4136.6	30	11.25$_2$

7162 *RS Aquilae.*

(Continued from 393.)

Julian	Calendar	Mag.
	1897	
4077.7	June 1	13.6]
4102.7	26	13.9]
4138.7	Aug. 1	12.0
4140.6	3	11.52$_2$
4159.6	22	11.1
4164.5	27	10.27$_2$
4166.6	29	10.37$_2$
4169.6	Sept. 1	10.09$_2$
4172.6	4	10.07$_2$
4182.6	14	10.21$_2$
4183.6	15	9.73$_2$
4186.5	18	9.76$_2$
4192.5	24	10.25$_2$
4193.5	25	10.06$_2$
4196.5	28	10.10$_2$
4200.5	Oct. 2	10.25$_2$
4206.5	8	10.60$_2$

7234 *W Capricorni.*

(Continued from 393.)

Julian	Calendar	Mag.
	1897	
4165.6	Aug. 28	11.40$_2$
4166.6	29	11.54$_2$
4170.6	Sept. 2	11.60$_2$
4183.5	15	11.69$_2$
4186.5	18	11.55$_2$
4189.5	21	11.57$_2$
4192.5	24	11.73$_2$
4195.5	27	11.68$_2$

7240 *RY Cygni.*

Julian	Calendar	Mag.
	1894	
3155.6	Nov. 22	8.6
3160.5	27	10.12
3167.5	Dec. 1	9.71$_2$
3169.5	6	10.19$_2$
3178.5	15	10.32$_2$
3180.5	17	10.10$_2$
3185.5	22	10.08$_2$

7240 *RY Cygni.*—cont.

Julian	Calendar	Mag.
	1895	
3195.5	Jan. 1	8.5
3327.6	May 13	9.9
3423.5	Aug. 17	9.6
3459.6	Sept. 22	8.7
3484.5	Oct. 17	9.8
3510.5	Nov. 12	8.5
3519.5	21	9.3
3540.5	Dec. 12	8.5
3543.6	15	9.90$_2$
	1896	
3712.7	June 1	8.7
3742.6	July 1	8.3
3858.5	Oct. 25	8.5
3862.5	29	8.7
3866.5	Nov. 2	9.73$_2$
3925.5	Dec. 31	9.64$_2$
	1897	
4106.6	June 30	9.71$_2$
4165.6	Aug. 28	9.72$_2$
4211.6	Oct. 13	9.87$_2$
4282.5	Dec. 23	9.84$_2$

7242 *S Aquilae.*

(Continued from 393.)

Julian	Calendar	Mag.
	1897	
4121.6	July 15	10.3r
4128.7	22	10.1r
4140.7	Aug. 3	9.7r
4142.6	5	9.6P
4157.6	20	10.1P
4161.6	24	10.0r
4165.6	28	10.1P
4172.6	Sept. 4	9.5r
4174.5	6	9.69$_2$
4182.6	14	9.34$_2$
4189.5	21	9.36$_2$
4194.5	26	9.01$_2$
4200.5	Oct. 2	9.48$_2$
4201.5	3	9.3P
4210.6	12	9.75$_2$
4215.5	17	10.29$_2$
4221.5	23	9.85$_2$
4225.5	27	10.65$_2$
4229.5	31	10.53$_2$
4232.5	Nov. 3	10.75$_2$
4247.5	18	9.95$_2$
4252.5	23	11.26$_2$
4256.5	27	10.85$_2$
4270.5	Dec. 11	10.41$_2$
4278.5	19	10.17$_2$
4283.5	24	9.78$_2$

7252 *W Capricorni.*

(Continued from 365.)

Julian	Calendar	Mag.
	1897	
4111.7	July 5	13.1]
4136.6	30	12.4
4138.7	Aug. 1	12.37$_2$
4142.6	5	11.85$_2$
4143.6	6	11.38$_2$
4157.5	20	11.91$_2$
4163.6	26	12.31$_2$

7260 *Z Aquilae.*

(Cont. from 393. Comp Stars 393)

Julian	Calendar	Mag.
	1897	
4078.7	June 2	12.0]
4094.7	18	12.0]
4102.7	26	12.5]
4108.6	July 2	12.6
4128.6	22	9.9
4128.6	22	9.9r
4136.6	30	9.95$_2$
4140.6	Aug. 3	10.63$_2$
4140.6	3	10.4r
4143.6	6	9.62$_2$
4144.6	7	9.81$_2$
4150.6	13	9.80$_2$
4151.6	14	9.91$_2$
4157.6	20	10.01$_2$
4157.6	20	9.5r
4161.6	24	10.4r
4164.5	27	10.07$_2$
4165.6	28	10.4r
4168.6	31	10.3r
4172.6	Sept. 4	10.8r
4174.5	6	10.79$_2$
4185.5	17	12.56$_2$
4192.5	24	13.1
4242.5	Nov. 13	11.9
4247.5	18	10.15$_2$

7261 *R Delphini.*

(Continued from 393)

Julian	Calendar	Mag.
	1897	
4121.5	July 15	8.58$_2$
4136.6	30	8.51$_2$
4140.6	Aug. 3	8.42$_2$
4143.6	6	8.29$_2$
4144.6	7	8.13$_2$
4145.6	8	8.22$_2$
4146.7	9	7.78$_2$
4148.6	11	8.11$_2$
4151.6	14	8.35$_2$
4155.6	18	8.58$_2$

7351 *RW Cygni.*

(Cont. from 393. Comp. stars 393)

Julian	Calendar	Mag.
	1897	
4096.7	June 20	9.4
4150.5	Aug. 13	10.17$_2$
4164.5	27	9.92$_2$
4174.5	Sept. 6	9.65$_2$
4176.5	8	9.79$_2$
4182.6	14	9.65$_2$
4192.6	24	9.61$_2$
4221.5	Oct. 23	9.41$_2$
4252.5	Nov. 23	9.79$_2$

7404 *R Microscopii.*

Julian	Calendar	Mag.
	1896	
3860.5	Oct. 27	10.7]
3888.5	Nov. 24	10.5]
	1897	
4173.6	Sept. 5	10.0]
4188.6	20	10.1
4192.6	24	9.7
4193.6	25	9.6
4195.6	27	9.47$_2$

7404 *R Microsc.*—cont.

Julian	Calendar	Mag.
	1897	
4198.6	Sept. 30	9.77$_2$
4201.6	Oct. 3	9.76$_2$
4206.5	8	9.40$_2$
4211.5	13	9.33$_2$
4215.5	17	8.91$_2$
4224.5	26	9.51$_2$
4228.5	30	9.56$_2$
4232.5	Nov. 3	9.82$_2$

7431 *S Delphini.*

(Continued from 372.)

Julian	Calendar	Mag.
	1897-8	
4252.5	Nov. 23	10.46
4256.5	27	9.88
4265.5	Dec. 6	9.89$_2$
4270.5	11	10.08$_2$
4277.5	18	9.96$_2$
4283.5	24	9.63$_2$
4287.5	28	10.17$_2$
4292.5	Jan. 2	10.29$_2$

7435 *Y Aquarii.*

Julian	Calendar	Mag.
	1896	
3742.6	July 1	10.2
3776.6	Aug. 4	10.9
3778.6	6	11.54$_2$
3787.6	15	11.1
3789.6	17	11.43$_2$
3790.6	18	11.93$_2$
3809.6	Sept. 6	11.4
3810.6	7	12.47$_2$
3840.5	Oct. 7	11.6
3859.5	26	11.7
3897.5	Dec. 3	12.3]
3918.5	24	12.3]
	1897	
4077.7	June 1	10.3
4094.7	18	10.1
4098.7	22	10.6
4103.7	27	10.4
4111.6	July 5	10.28$_2$
4114.6	8	10.4
4115.6	9	10.70$_2$
4137.6	31	10.71$_2$
4144.6	Aug. 7	11.11$_2$
4164.6	27	10.9
4168.6	31	11.53$_2$
4185.6	Sept. 17	12.50$_2$
4194.6	26	12.71$_2$
4214.5	Oct. 16	12]
4224.5	26	13.0
4241.5	Nov. 12	13.0]
4253.5	24	11.5]

7448 *W Aquarii.*

Julian	Calendar	Mag.
	1896	
3755.6	July 14 to	
3918.5	Dec. 24	11.5]
	7 dates	
	1897	
4077.7	June 1	10.9
4094.7	18	10.9
4098.7	22	11.1
4103.7	27	11.1

7148 *W Aquarii.*—cont.

Julian	Calendar	Mag.
	1897	
4111.6	July 5	11.2
4114.6	8	11.8
4115.6	9	11.70_2
4137.6	31	11.2]
4157.6	Aug. 20	12.1]
4224.5	Oct. 26	12.6]

7450 *V Aquarii.*

Julian	Calendar	Mag.
	1897	
4140.6	Aug. 3	9.1r
4157.6	20	9.1r
4163.6	26	9.1r
4168.6	31	9.1r

7450 *V Aquarii*—cont.

Julian	Calendar	Mag.
	1897	
4172.6	Sept. 4	9.1r
4182.6	14	8.99_2
4192.5	24	8.98_2
4198.5	30	8.97_2
4201.5	Oct. 3	9.1r
4206.5	8	8.72_2
4215.5	17	8.73_2
4215.5	17	9.0r
4224.5	26	9.0r
4225.5	27	9.07_2
4235.5	Nov. 6	8.97_2
4247.5	18	8.41_2
4252.5	23	9.13_2

7450 *V Aquarii.*—cont.

Julian	Calendar	Mag.
	1897	
4252.6	Nov. 23	9.0r
4253.5	24	9.0r
4264.5	Dec. 5	8.90_2
4271.5	12	9.1r
4278.5	19	9.1r

7455 *U Capricorni.*

(Continued from 392.)

Julian	Calendar	Mag.
	1897	
4128.5	July 22	11.0
4128.7	22	10.8r
4136.7	30	10.74_2
4136.7	30	10.6r

7455 *U Capric.*—cont.

Julian	Calendar	Mag.
	1897	
4138.7	Aug. 1	10.8
4140.6	3	10.97_2
4140.7	3	10.7r
4142.6	5	10.6r
4157.6	20	10.6r
4163.6	26	10.9r
4168.6	31	11.2r
4172.7	Sept. 4	11.4r

7456 *RR Cygni.*

(Continued from 393.)

Julian	Calendar	Mag.
	1897	
4168.6	Aug. 31	8.9r

7456 *RR Cygni.*—cont.

Julian	Calendar	Mag.
	1897	
4176.6	Sept. 8	9.10
4177.5	9	9.00_2
4182.6	14	9.05_2
4192.6	24	9.24_2
4198.6	30	9.22_2
4206.5	Oct. 8	9.09_2
4215.5	17	9.25_2
4228.5	30	8.75_2
4231.6	Nov. 2	9.22_2
4241.5	12	9.12_2
4252.5	23	8.77_2
4265.5	Dec. 6	9.33_2
4278.5	19	9.27_2

6940. I have found no decisive change in four years.
7240. Very little variation in four years; a min. about 1894 December, and a max. about 1896 September.
7252. My intervals make the period successively, 215, 207, and 213 days.
7455. (—20.) Max. derived from one factor and two observations only.

Comparison-Stars.

6903 *T Sagittarii.*

1893–1897

Star	DM.	Mag.	*n*
C	−17°5535	7.26	1
H	−17°5564	8.00	25
1*H*	−16°5232	8.28	6
J	−16°5259	8.31	21
K	−17°5555	8.48	22
L	−16°5238	8.38	5
N	−16°5209	8.38	8
1*R*	−17°5540	9.02	35
U	−17°5545	9.89	21
W	−17°5556	9.64	3
X	−17°5557	10.33	2
1*X*	−17°5550	10.97	1
a	5*n*6*f* *V*	10.63	14
c	3*f* *V*	11.10	11

6921 *S Sagittarii.*

1893–1897

Star	DM.	Mag.	*n*
I	−18°5298	7.43	9
1*I*	−19°5398	7.40	9
2*I*	−19°5387	7.24	9
N	−19°5388	8.22	24
1*N*	−18°5299	8.14	16
2*N*	−19°5376	8.42	2
3*N*	−19°5386	8.53	10
T	−19°5384	9.07	5
U	−19°5390	9.30	12
2*W*	−19°5396	9.87	13
3*X*	−19°5405	9.71	9
1*Y*	−19°5397	11.09	22
Z	−19°5385	10.42	2
c	9*s* 1*Y*	11.05	17

7252 *W Capricorni.*

1893–1897

Star	DM.	Mag.	*n*
N	−22°5366	9.29	1*P*
Q	−21°5654	9.70	0
U	−22°5367	10.47	3
1*U*	−22°5364	10.68	0
2*U*	−22°5379	10.57	3
W	−22°5374	10.66	3
1*W*	−22°5371	10.95	1*P*
X	−22°5368	11.73	1
b	7*s*3*p* *W*	12.11	16
c	5*s*14*f* *W*	10.92	8
d	5*s*2*f* *b*	11.45	17
f	4*s*1*p* *N*	11.68	18
h	4*n*6*f* *W*	12.35	19
m	4*n* *W*	13.14	9

7261 *R Delphini.*

1893–1897

Star	DM.	Mag.	*n*
M	+9°4452	8.47	15
N	+8°4376	8.98	20
P	+9°4460	8.62	10
Q	+8°4383	8.91	29
R	+9°4443	8.87	3
3*T*	+9°4446	8.29	9
U	+9°4450	9.93	6
W	+9°4459	10.35	6
X	+8°4384	10.43	2
1*X*	+8°4385	10.08	7
Z	+8°4388	10.25	6
d	8*s*4*f* *Q*	11.23	3
j	6*f* *Q*	12.34	3
k	2*n*4*f* *X*	12.55	4

CONFIRMATION OF VARIABILITY,

By R. T. A. Innes.

[Communicated by Dr. David Gill, C.B., F.R.S., etc., H.M. Astronomer, Cape of Good Hope.]

Lac. 8051 (1875) $19^h\ 8^m\ 24^s$ $-33^\circ\ 44'.4$*.

The variability of this star was pointed out by Prof. Kapteyn in *A.N.* 2987 from Cape Photographic plates. Recent visual observations with the 7-inch refractor confirm this result. We have

		M
Lacaille,	1751	7.0
Cordoba,	1873 Sept. 1	7.0
"	1874 Sept. 19	7.0
"	1874 Sept. 23	7.0
Cape,	1877	7.0
Cape Photo.,	1888 Oct. 22–25	10.2
Cape Photo,	1890 Oct. 30–Nov. 3	7.2
" "	1890 Nov. 14–Nov. 19	7.1
Cape, 7-in. visual,	1897 Oct. 14–20	11.0
" " "	1897 Oct. 28–31	10.2
" " "	1897 Dec. 1	8.8

Also, the star does not appear in the Washington Zone of 1846 July 14, when surrounding stars to the 9.0 mag. were recorded.

Cord. DM. $-32^\circ12146$ (1875) $16^h\ 47^m\ 8^s.8$ $-32^\circ\ 25'.0$.*

Suspected at Cordoba: $7\frac{3}{4}^M$ to $9^M.5$.

Cape, Visual 7-in. 1896 Aug. 16–1897 Oct. 20, $7^M.5$ to $8^M.8$.
Color = 7.7.

Royal Observatory, Cape of Good Hope, 1897 *Dec.* 2.

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* This star is already in the list of known variables, and is 6901 *RY Sagittarii* (*A.J.* xvii, 64). It was originally discovered by Markwick (*A.N.* 141,35), and independently by Kapteyn (*A.N.* 142,75). The reference to *A.N.* 2987 in the foregoing article is doubtless an inadvertence, since the star is not mentioned in the article by Kapteyn in that place. The variability has also been confirmed by Mrs. Fleming from the H.C.O. Photographs. — Ed.

* The data given by Thome and Innes seem to make the variability certain, and accordingly the definitive notation may be assigned as

		h m s	° ′
6053 *SS Scorpii*	(1900)	16 48 46	—32 27.6
	(1855)	16 45 51	—32 22.9

Ed.

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENNA., WITH A 4½-INCH REFRACTOR,

BY A. W. QUIMBY.

1897	Time	New Grs.	Total		Fac Grs.	Def.	1897	Time	New Grs.	Total		Fac. Grs.	Def.	1897	Time	New Grs.	Total		Fac Grs.	Def.
			Grs.	Spots						Grs	Spots						Grs.	Spots		
July 1	7		2	11	2	fair	Aug. 29	7	–	1	2	–	poor	Oct. 29	8	–	–	–	1	fair
2	7		2	15	1	fair	30	7	1	1	1	1	fair	30	8	–	–	–	1	fair
3	9	1	3	12	2	fair	31	7	–	1	6	1	poor	31	8	1	1	3	–	fair
4	6	–	2	10	1	poor	Sept. 1	7	3	4	28	3	good	Nov. 2	8	1	1	1	1	poor
5	7	–	2	10	1	poor	2	7	–	4	21	3	fair	3	8	–	1	2	2	good
6	7	–	2	4	1	fair	3	7	–	4	57	3	fair	4	8	–	1	3	3	fair
7	7	1	3	5	1	fair	4	7	–	3	11	1	fair	5	2		1	7	3	good
8	7	1	4	10	1	poor	5	7	–	3	72	–	good	6	3	–	1	5	2	good
9	7	–	1	10	1	poor	6	7	–	3	57	–	good	7	8	–	1	3	1	good
10	7		3	1	1	fair	7	7	–	3	33	1	poor	9	11	–	–	–	–	poor
11	8	–	2	3	1	fair	8	7	–	3	26	–	poor	10	2	–	–	–	1	good
12	7	–	2	8	–	poor	9	7	–	3	98	1	good	11	9	–	–	–	–	poor
13	6		1	2	–	v.poor	10	7	–	3	17	1	good	12	8	2	2	5	2	fair
14	7	2	3	12	1	fair	11	7	–	3	32	1	fair	13	1	–	2	5	–	poor
15	7	1	4	19	1	fair	13	10	–	1	2	–	poor	14	8	–	1	4	–	fair
16	7	–	2	8	2	fair	14	7	2	3	7	1	fair	15	8	–	–	–	–	fair
17	7		1	2	1	poor	15	7	1	1	2	1	fair	16	8	1	1	1		poor
18	5	–	1	1	1	poor	16	9	–	1	1	1	poor	17	8	–	1	3	1	fair
19	5	1	2	3	–	poor	17	7	1	2	2	1	poor	18	8	–	1	1	1	fair
20	8	1	1	1	–	v.poor	18	7	1	3	11	2	good	19	11	1	1	1	2	poor
21	9		2	7	2	poor	19	7	1	4	13	2	good	20	11	1	2	3	3	fair
22	8	–	2	16	1	poor	20	7	–	3	12	1	fair	21	8	–	2	3	4	fair
23	7	–	2	18	1	fair	21	7	1	4	20	2	poor	22	8	–	–	–	3	poor
24	7	–	2	24	–	fair	22	7	–	3	18	1	poor	23	8	–	–	–	1	fair
25	7	–	2	26		fair	24	7	–	2	20	1	fair	24	8	–	–	–	2	fair
28	4	–	2	10	–	poor	25	7	–	2	32	2	good	25	8	1	1	1	–	poor
29	7	1	3	17	1	good	26	7	1	3	22	1	fair	26	1	–	1	2	–	poor
30	7	–	3	12	4	fair	27	7	1	4	29	3	fair	27	8	1	1	2	1	poor
31	7	1	4	9	3	fair	28	7	–	4	10	4	fair	28	8	–	1	2	–	poor
Aug. 1	7	1	2	6	3	fair	29	7	2	5	9	2	fair	29	3	1	2	10	–	poor
2	7	1	2	6	2	fair	30	7	–	5	12	3	fair	30	11	–	2	10	1	poor
*3	9	–	2	5	1	poor	Oct. 1	7	–	4	10	2	fair	Dec. 1	10	–	2	12	1	poor
*4	8	1	2	5	1	poor	2	7	–	4	7	2	good	2	8	–	2	5	–	v.poor
*5	7	1	4	16	2	fair	3	9	–	3	5	–	poor	5	9	3	3	28	2	fair
*6	6	–	3	27	–	good	4	7	2	5	7	1	fair	6	11	1	4	12	–	poor
*7	6	–	3	23		good	5	7	–	5	7	2	fair	7	9	1	5	29	2	fair
*8	7	–	3	28	1	good	7	7	–	3	7	2	fair	8	10	–	4	39	2	fair
*9	8	–	3	18	1	fair	8	7	–	3	7	3	fair	9	10	1	3	51	2	fair
*10	7		2	12	2	poor	9	7	–	–	–	3	fair	10	10	–	3	34	2	fair
*11	7	–	2	8	–	fair	10	7	–	1	1	2	fair	11	2		3	30	–	poor
*12	6	–	2	18	–	fair	11	11	–	1	2	–	fair	12	8	–	3	22	1	poor
*13	7	–	2	23	2	good	12	3	1	1	3	1	fair	13	1	–	2	66	1	fair
14	6	–	2	7	2	poor	13	7	–	1	1	1	fair	15	2	2	3	20	1	poor
15	7	–	1	9	2	fair	*14	9		1	1	–	fair	16	9	1	4	47	2	fair
16	7	1	2	5	2	poor	*15	9		2	4	–	fair	17	9	–	3	10	1	poor
17	7	–	1	1	1	fair	*16	10	–	2	2	–	poor	18	9	–	3	10	–	poor
18	7		1	1	1	fair	*17	7	–	2	7	–	fair	19	9	–	3	12	2	fair
19	7	–	1	1	–	fair	*18	7	–	–	–	–	fair	21	10	–	–	–	–	v.poor
20	7	–	1	1	1	fair	*19	2	–	–	–	–	poor	23	11	–	1	1	1	fair
21	7	–	1	1	–	fair	*20	9	–	2	2	–	poor	24	10	–	–	–	1	poor
22	8	1	2	7	–	poor	*22	7	–	–	–		poor	25	9	–		–	1	fair
23	7	1	2	2	–	poor	*23	7	–	–	–	–	poor	26	1	1	1	1	2	fair
24	8	–	2	5	–	poor	*24	1	–	1	1	1	fair	27	9	1	2	5	2	fair
25	7	–	2	3	–	poor	*25	8	–	–	–	1	poor	28	9	–	1	9	2	good
26	7	–	2	3	1	poor	26	8	–	–	–	2	poor	29	9	1	2	3	1	poor
27	7	–	3	7	1	fair	27	8	–	–	–	2	poor	30	9	1	3	4	1	fair
28	7	–	1	2	–	poor	28	8	–	–	–	2	poor							

* 2½-inch refractor.

LIST No. 6 OF NEBULAS DISCOVERED AT THE LOWE OBSERVATORY,

By LEWIS SWIFT.

No.	Date	R.A. (1900)	Decl. (1900)	Description.
	1897	h m s	° ′ ″	
1	Dec. 25	2 11 10	−31 39 15	pF, pS, R, dist. D nf
2	22	2 25 45	−34 42 0	eeeF, S, R, D nearly p, np of 2
3	22	2 26 0	−34 41 42	eF, eS, R, ft st near n, D np, sf of 2
4	22	2 26 15	−36 28 55	pB, pS, vE
5	22	2 37 0	−28 37 0	eeF, S, R, 3 fine D nf each about 7″
6	22	2 40 35	−28 22 35	eeF, S, R, D np
7	22	3 7 30	−25 42 0	eeF, S, R, 2 ft st near sp point to it
8	26	3 35 40	−27 11 10	eF, eS, lE, st close nf, stellar
9	26	3 50 40	−28 26 15	eF, S, R, F st in contact nf
10	23	4 8 30	−32 49 48	vF, vS, R, partial resolv. susp., 1531-2 in field
11	26	4 52 0	−28 41 35	eeeF, pL, iR, D 24ˢ f points to it
12	Nov. 30	5 2 30	−20 37 15	eeeF, pS, bet. 2 st close to eeeFD, eee dif
13	Dec. 26	5 15 10	−25 11 30	eeeF, S, R, 7ᴹ 15ˢ p ls nearly obliterates it, eee dif
14	1	5 30 0	−23 36 30	eeF, S, R, 7ᴹ close p, sf of 1980
15	Nov. 30	5 44 0	−30 31 55	eeeF, pS, R, F np, sev B st sf, 3 st n curved
16	Dec. 1	5 53 0	−23 11 30	pB, pS, R, in vacancy, sev B st f
17	1	5 56 45	−23 41 30	B, L, R, bet. st nf and v wide D np
18	1	6 1 5	−27 51 50	vF, pS, lE, st in contact nf, n end like a brush
19	28	9 18 10	−22 2 55	pF, cS, vE, 10ᴹ close sp
21	28	10 11 20	−33 3 10	eeF, pS, iR, in center trapezium
22	30	10 16 38	−33 16 15	vF, CS, R, 9ᴹ pr close f
23	30	10 24 30	−35 3 15	eeeF, eeS, R, eF st in contact s, p of 2
24	30	10 35 12	−35 31 35	eeeF, eeS, R, eF st in contact s, f of 2
25	29	10 36 0	−35 5 25	eeeF, eS, R, eeF D near S

NOTES TO Nos. 23 AND 24.

Here are two nebulas singularly placed, whose descriptions, as will be seen, are identical in every particular. I ran across a very faint nebula which I found to be N.G.C., No. 3267. Near following was an exceedingly faint and very close double star, which, with a power 132, looked as if the north one was an exceedingly small nebula of unimagined faintness. With a power of 200, my suspicion that it was not a star was confirmed. In a few minutes I ran across another, which in every particular was exactly like it, both being north of its companion star, and the same distance apart, about 4″, and of the same size and faintness. But for the excellent seeing and superiority of my periscopic eye-piece for revealing faint nebulas, they would have escaped detection.

Echo Mountain, California.

ON THE ROTATION-VELOCITY OF THE EARTH,

By H. Y. BENEDICT.

For a special case of the earth regarded as a body of variable form an integral can be obtained which does not appear to be wholly destitute of interest.

Using Tisserand's notation (*Mécanique Céleste*, T. II, Ch. XXX), and assuming $A, B, C, f_1', g_1', h_1'$, to be constants, the equations of motion, referred to the principal axes of the earth, are

$$A\frac{dp}{dt} + (C-B)\,qr + h_1' q - g_1' r = \frac{\sin\varphi}{\sin\theta}\left(\frac{\partial U}{\partial\psi} + \cos\theta\,\frac{\partial U}{\partial\varphi}\right) - \cos\varphi\,\frac{\partial U}{\partial\theta}$$

$$B\frac{dq}{dt} + (A-C)\,rp + f_1' r - h_1' p = \frac{\cos\varphi}{\sin\theta}\left(\frac{\partial U}{\partial\psi} + \cos\theta\,\frac{\partial U}{\partial\varphi}\right) + \sin\varphi\,\frac{\partial U}{\partial\theta}$$

$$C\frac{dr}{dt} + (B-A)\,pq + g_1' p - f_1' q = \frac{\partial U}{\partial\varphi}.$$

Multiplying respectively by p, q and r, and adding the products,

$$\begin{aligned}Ap\frac{dp}{dt} + Bq\frac{dq}{dt} + Cr\frac{dr}{dt} &= \frac{1}{\sin\theta}\,(p\sin\varphi + q\cos\varphi)\,\frac{\partial U}{\partial\psi}\\ &\quad + \left[r + \frac{\cos\theta}{\sin\theta}\,(p\sin\varphi + q\cos\varphi)\right]\frac{\partial U}{\partial\varphi}\\ &\quad + (q\sin\varphi - p\cos\varphi)\,\frac{\partial U}{\partial\theta}\\ &= \frac{\partial U}{\partial\psi}\frac{d\psi}{dt} + \frac{\partial U}{\partial\varphi}\frac{d\varphi}{dt} + \frac{\partial U}{\partial\theta}\frac{d\theta}{dt}\\ &= \frac{dU}{dt} - \frac{\partial U}{\partial t} \quad : \quad \text{since} \quad U = F(\psi, \varphi, \theta, t)\end{aligned}$$

Hence, integrating,

$$Ap^2 + Bq^2 + Cr^2 = 2U + \text{const} - 2\int\frac{\partial U}{\partial t}\,dt$$

By referring to the development of U given in Chapter XXV of the work just cited, it is seen that neither U nor $\int\frac{\partial U}{\partial t}\,dt$ contains secular terms, and hence the same is true of $Ap^2 + Bq^2 + Cr^2$. Therefore, if r has a secular term, so has the angle between the instantaneous axis of rotation and the axis of figure.

Harvard University, 1898 *Jan.* 11.

OBSERVATIONS OF VARIABLES,

BY HUGH WRIGHT.

Having received, through the kindness of Mr. R. T. A. INNES, maps of the regions showing some of the variable stars discovered by him at the Royal Observatory, Cape Town, during the present year, I made the following observations, using an 8½-inch With-reflector and a magnifying power of 60.

Oe. Arg. 10288 (1875) 12h 54m 7s –19° 16'.7

This star does not appear to be variable. From observations made on 32 nights, between March 5 and August 28, its magnitude appears to be 9.5. On some hazy nights 9M.4 and 9M.3 have been registered.

Cord. Z.C. 13h2483 (1875) 13h 44m 2s –36° 14'.2.*

1897	M	1897	M	1897	M
Mar. 5	9.2	Apr. 26	9.0	May 10	9.0
6	9.2	27	9.0	11	9.0
7	9.3	30	9.1	23	8.9
8	9.2	May 1	9.1	26	9.0
9	9.2	2	9.1	June 2	9.0
29	9.2	3	9.4	29	9.4
30	9.2	4	9.1	July 2	9.3
31	9.3	5	9.0	5	9.5
Apr. 1	9.3	6	9.1	Aug. 25	10.5
2	9.2	7	9.0	28	invis.
13	9.2	8	8.9		
19	9.3	9	9.0		

Cord. Z.C. 15h4006 (1875) 15h 57m 8s –23° 15'.2.*

1897	M	1897	M	1897	M
Apr. 30	9.6	May 8	9.9	July 5	9.9
May 1	9.7	9	9.9	28	9.6
2	9.8	11	9.9	Aug. 19	9.4
3	9.7	23	10.0	23	9.5
4	9.8	26	10.0	25	9.4
5	9.8	June 2	10.3	28	9.4
6	9.8	29	10.1	30	9.4
7	9.9	July 2	10.0		

Cord. Z.C. 16h2278 (1875) 16h 32m 36s –32° 7'.9.

1897	M	1897	M	1897	M
May 3	8.0	May 9	7.8	July 5	8.4
4	8.0	11	8.3	28	9.0
5	8.0	23	8.3	Aug. 25	9.0
6	8.2	26	8.2	28	9.0
7	8.0	June 2	8.2	30	9.0
8	7.8	July 3	8.3		

All estimates made by comparison with neighboring stars, and independent of previous night's determination.

Public Library, Sydney, N.S.W., 1897 Dec. 1.

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* 4935 *RT Centauri.* See *A.J.* 414, p. 46. — ED.

* 5752 *RZ Scorpii.* See *A.J.* 414, p. 46. — ED.

EPHEMERIS OF WINNECKE'S COMET, *a* 1898.

(Continued from *A.J.* 424.)

1898	App. α	App. δ	log Δ	1898	App. α	App. δ	log Δ
	h m s	° ' "			h m s	° ' "	
Feb. 7.5	17 51 3.34	–12 1 18.5	0.1457	Mar. 7.5	20 19 37.83	–14 31 3.7	0.1340
9.5	18 4 0.23	21 40.1		9.5	30 6.29	28 58.1	
11.5	14 2.88	40 49.7	0.1400	11.5	40 31.13	25 6.6	0.1350
13.5	24 12.71	–12 58 42.2		13.5	20 50 51.58	19 30.1	
15.5	34 28.36	–13 15 12.5	0.1356	15.5	21 1 6.99	12 12.0	0.1420
17.5	44 49.18	30 15.4		17.5	11 16.69	–14 3 14.8	
19.5	18 55 14.35	43 47.1	0.1326	19.5	21 19.97	–13 52 43.2	0.1473
21.5	19 5 43.16	–13 55 43.1		21.5	31 16.28	40 41.0	
23.5	16 14.76	–14 6 0.8	0.1310	23.5	41 5.15	27 13.4	0.1533
25.5	26 48.40	14 36.4		25.5	21 50 16.01	–13 12 24.9	
27.5	37 23.22	21 28.2	0.1307	27.5	22 0 18.56	–12 56 20.8	0.1600
Mar. 1.5	47 58.61	26 33.5		29.5	9 12.26	39 6.8	
3.5	19 58 33.08	29 51.8	0.1317	31.5	22 18 57.29	–12 20 49.4	0.1671
5.5	20 9 6.50	–14 31 21.6					

A. H.

CORRIGENDUM.

A.J. 422, p. 112, line 32, *for* +77 12' 25".4 *put* +77 12' 20".4.

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REMARKS ON THE PRECESSIONAL MOTION: A REJOINDER,

By SIMON NEWCOMB.

As the remarks of Professor Boss in *A.J.*, No. 423, still show some misconception of my work on the above subject, and of my attitude in the matter, I must ask leave to make a rejoinder.

The human relations of the subject are so prominent, that I must begin with them. I regret exceedingly if anything I said in No. 413 justifies the interpretation of being a call upon astronomers to adopt my results. What are the facts? Simply these: I published several months ago a discussion of the precessional motion. In *A.J.*, No. 410, Boss published certain strictures on the work and on the action of the Paris Conference in relation to it, which seemed to me to be based very largely on misconceptions. I therefore replied by a statement of the objects of the work and of the character of its results. Quite possibly the title: "Reasons for the Adoption," etc., was unfortunate. I therefore wish in starting out to disclaim in the strongest manner any desire to force the conclusion that my work ought to be adopted. There are two sides to every question, and I should have said nothing on either side had Boss showed a complete understanding of the work. Moreover, I claim no merit whatever for the work. But as Professor Boss wholly ignores what I said of its intended purposes, I ask leave first to state them explicitly.

I. We may fairly anticipate that the next half century will be one of great developments in exact stellar astronomy. The hoped-for re-reduction of the older series of observations with modern data; continued investigations into the errors which affect determinations of star-positions; the extension of observations to great masses of fainter stars; the addition of new adjuncts to methods of observations, especially photography and the heliometer; such researches as those of Kapteyn on stellar motions and distances; — all these will lead to something like a definitive solution of problems concerning stellar motion, structure of the sidereal system, etc. I fully agree with Boss that all these should really constitute a single general and indivisible problem.

By much troublesome experience during recent years, I find that a most necessary adjunct to such researches as these is a theory and formulae of the precessional motion which shall be fairly near the truth, and theoretically so self-consistent that, whether reductions from one epoch to another are made by longitudes, by trigonometric reductions, or by using annual variations, the results will be the same, to 0″.01 per century, however great the proper motion of the star may be; so that, if discrepancies are found, the astronomer shall know at once that they do not proceed from defective data of reduction. This preliminary want I have tried to satisfy by constructing formulae and quantities having the required degree of self-consistency, and as precise as, in my judgement, the available data would permit. The questions whether this end is worth the trouble and whether I have succeeded, I leave to others.

The ground which seems to be taken by Professor Boss and others is that, if we will wait only a short time, we shall have the definitive solution of all these problems, and with it a definitive value of the constant of precession. I can only reply to Professor Boss's rhetorical remarks at the bottom of page 115, column 1, that our successors will show great energy if they carry out the programme I have outlined within fifty years.

II. His objections to the proceedings of the Paris Conference are worthy of note. By reference to p. 54 of the *Procès-Verbaux* it will be seen that the Conference resolved in favor of the adoption, in the respective ephemerides represented, of certain values of the astronomical constants of reduction, but said nothing about their adoption by astronomers generally. Professor Boss calls this "assuming to legislate for astronomy in general," a matter of "decree," and the logical opposite of "examination and judgement." The question whether this is a correct use of language I must leave to be decided by competent linguistic authority.

III. Passing to particulars: In his starting summary he says:

"There is no emergency calling for the immediate adoption of new values of the precessional motion."

I agree with this, and go yet farther. Astronomers may go on indefinitely using patched-up values of the precessional motion in their investigations of proper motion, without creating anything which would be an "emergency" in the sense in which that term is defined by lexicographers.

"The study of the precessional motion ought to be more effectively connected with the definitive solution of problems concerning solar motion, structure of the sidereal system and systematic errors in observed star-positions."

I reply that my work is constructed as nearly on this plan as my limited powers and limited means permitted. The 38 pages, from 19 to 57, are very largely taken up with this very combination. The one main point in which Boss may claim that they fail of coming up to his standard is in not being "definitive." He and some others seem to think that a time is approaching, when astronomers will all agree as to what are the most probable values of astronomical constants. I thought so myself ten years ago, but am now convinced that the hope is ill-founded. In my judgement, nothing in astronomy will be accepted as really "definitive" for several generations to come, if ever. His main point is, in effect, that I have omitted existing material which would have added in an important degree to the accuracy of my results. Here I take issue with him. Much that he says on this subject seems to me too weak to demand reply, and I shall devote attention mainly to the strongest points.

IV. The precession in right-ascension is determined from the observed increase of right-ascension of stars with the time. If the stars had no proper motion its determination would involve no difficulty. Bright stars have larger proper motions than faint ones, and are fewer in number; therefore it was supposed until recently that we should rely mainly on faint stars. Now it is known that an error of personal equation is introduced into the observed right-ascensions of faint stars, because their position has to be determined relative to the bright ones used as fundamental. If we take two epochs, t_0 and t_1, the error of the result will come out in the form

$$\epsilon = \frac{\Delta\alpha_1 - \Delta\alpha_0}{t_1 - t_0}$$

Here $\Delta\alpha_0$ and $\Delta\alpha_1$ are the personal equations depending on magnitude in the right-ascensions at the two epochs. Now, we can determine $\Delta\alpha_1$ by investigation, but we cannot determine $\Delta\alpha_1$ for the astronomers who observed a century ago until we learn what the precession really is. Professor Boss does not explicitly say so, but he seems to imply that in his opinion this error a hundred years ago was zero. If he takes this ground he does so by the familiar method of reaching a conclusion, setting forth the cases favorable to it, and ignoring those which are against it.

There are two ways of diminishing the error of our determination of the precessional motion. One is by waiting to get a larger value of $t_1 - t_0$. The other is by getting determinations from which this error is eliminated. If we suppose that, by the A.G. zones, we are able to eliminate this result for certain observations of the epoch 1880, then by 1930 we shall have half a century of observations from which this particular error is eliminated.

The other method is by ignoring the errors in question. In this way their effect will diminish as the reciprocal of the time.

V. I now pass to the declinations, which is that branch of the matter that most needs clearing up. Here, to show how deceptive is Professor Boss's picture of the great value of the material I have omitted, I must begin by analyzing the matter.

The determination of the precessional motion from declinations is subject to two sources of error, the one systematic, the other accidental. The only systematic errors which directly influence the result are those of the form $k \cos \alpha$, which belong to the class of errors in declination depending on the right-ascension. It is impossible to make any approximate evaluation of the probable amount of this error, except by general judgement, and by comparing the results of the best authorities at various epochs. So far as it enters into my determination I have, with much uncertainty, supposed its probable amount to be $\pm 0''.10$. But it may possibly amount to $\pm 0''.20$ per century. The second, or accidental errors, arise mainly from the variety of the proper motions. This admits of a fairly precise estimation, and I have already given the value $\pm 0''.09$ as a fair estimate of its probable amount. Now, so long as we use one and the same standard system of reference, no increase in the number of stars will diminish the first, or systematic error. If the systematic error is $\pm 0''.10$, then the addition of an infinite number of faint stars to those I have used would only reduce the probable error from $\pm 0''.14$ to $\pm 0''.10$. If the systematic error be $\pm 0''.20$, the reduction would only be from $\pm 0''.22$ to $\pm 0''.20$.

Now, on page 116, column 1, Professor Boss gives a very imposing list of the authorities which I have omitted, including Greenwich, Dorpat, Edinburgh, etc., between 1820 and 1850. But I do not know whether he means that this would have diminished the systematic or the accidental error. If he means the systematic error, I would reply that, substantially, I have used all that would strengthen the system of declinations. It is true that I did not blindly follow Boss's standard by reducing either Bradley's observations or those of 1865 to it. I found that by blindly following it the precessional motion would not be altered by more than 0″.10 per century, and I concluded that even this small difference was due to the weakness of the comparison rather than to systematic error. I therefore believe that the results I got are substantially those which would result from the most complete elimination of the systematic error by the use of all standard authorities.

The objections to including the 12000 to 15000 star-places which he talks about are these:

First. It is impossible to certainly reduce them to any well-established standard, so that, except by a thorough revision of the entire work of constructing the catalogues, no reliable result could be derived. The results which we should get would be of that class which we are going to accept if they agree with others, and reject if they do not.

Second. In any case, the addition of all this material would only have diminished the accidental portion of the error and not diminished the systematic part.

VI. I now pass to the strongest point which I can extract from the paper under review, and which I can strengthen by my own statements. It would have been exceedingly desirable to introduce stars of the southern hemisphere which cannot be accurately observed in our latitudes, say all those south of $-30°$. I actually did set out to do this by a study of the material at hand. The conclusions I reached were these: —

The earliest positions which admitted of reduction to a standard are those of the Cape Catalogue for 1840. The latest were those of the Cape observations between 1875 and 1889. The mean interval was about 45 years. Even for the Cape Catalogue of 1840 the material for reduction to a standard was weak. For example, one could not determine the reduction $\Delta\alpha_\delta$ nor form an idea how large it might be. Moreover, when all the available stars were collected, they were found to be only a few hundred in number. Even for these few, the accidental and systematic errors would be doubled in the centennial precession from the fact that $t_1 - t_0$ would be only 0.45, while for BRADLEY it was greater than unity. I therefore decided to reject the material.

In stating this conclusion, I by no means claim to have been infallible. If Professor BOSS or any other astronomer will make as careful an examination of the southern catalogues as I did, having in view the various classes of systematic and accidental errors to which they are liable, and thus form an estimate of how much their introduction would have subtracted from the probable error of the resulting constant of precession; this by computation and not by rhetoric; I shall gladly accept his results.

As the matter stands it seems to me that Professor BOSS's implied conclusion — that, because there are 15000 stars of which satisfactory values of the proper motion can be computed, therefore these proper motions can be used to strengthen the value of the constant of precession — is fallacious. He leaves out of consideration the important fact that a value of the precessional motion derived from this material, though its probable error computed in the usual way would be very small, would be subject to systematic errors so large as to be of little real value.

NOTE ON VELOCITIES,

BY A. HALL.

In Circular No. 21 of the Harvard Observatory, Professor PICKERING gives the orbital velocities of *μ' Scorpii*, the binary character of which was discovered by Prof. BAILY, and of Cord. G.C. 10534, discovered by himself, as 286 and 379 miles per second respectively. It is interesting to compare these results with similar motions in our solar system, and with the motions in space of stars that have great proper motions. The formula for the velocity under the Newtonian law of attraction is

$$V^2 = \mu \left\{ \frac{2}{r} - \frac{1}{a} \right\}$$

V being the velocity, μ the sum of the masses of the attracting bodies, r the radius-vector, and a the semi-major axis of the conic. This formula gives for the mean velocities of *Mercury*, the *Earth*, and *Neptune*,

29.6 ; 18.4 ; and 3.4 miles.

For a parabola the formula becomes

$$V = (18.4) \, . \sqrt{\frac{2}{r}} = \frac{26}{\sqrt{r}}$$

Hence for the velocities at perihelion of the great comets of 1843, 1880, and 1882, we have

351 ; 338 ; and 295 miles.

These velocities are comparable to those of the stars given above, but they continue for only a short time. These comets passed within about 100000 miles of the surface of the sun, but the motions were in accordance with the law of gravitation. In some cases the nucleus of the comet was broken into several parts, probably by the action of the sun, and this has happened with several other comets. The great stellar velocities in orbital motion indicate a small distance of the stars from each other, and perhaps also the great mass of the system. There appears to be no want of stability in such orbits, unless it may arise from the interaction of the stars, but of this we cannot judge until their distance from each other is known.

The discovery by KAPTEYN of a star with a proper motion of 8″.7, and which may have a greater motion in space than 1830 Groombridge, calls attention to these velocities. Here no departure has been observed from rectilinear motion. The formula for the velocity shows that if a body moved in a hyperbola having a small major axis the velocity may be great. Thus if

$$a = -0.1 \quad ; \quad r = 1 \quad ; \quad \text{and} \quad \mu = 9$$

the velocity is 191 miles, and after the lapse of an infinite time the velocity would be 175 miles. In such cases it is probable that we see the greatest component of the velocity, and although in these orbits the stars must finally disappear they would continue of nearly the same magnitude for a long time. If we assume the parallax of the star to be 0″.1, and suppose the star to be moving toward, or away from our sun 200 miles a second, the light of the star in a century would change in the ratio of 1007 to 1000.

In the *Berlin Memoirs* for 1760 **Euler** has considered the motion of a body attracted toward two fixed centers, and has reduced the solution to elliptic integrals. In the first volume of his *Fonctions Elliptiques*, **Legendre** has discussed several forms of the solution, and has drawn curves to illustrate the orbits. Denote by A and B the forces at the fixed centers, and let the distance AB be a. Take the origin on this line and call the x-coordinate of A, x, and that of B, u, so that $x+u = a$. Let r be the radius-vector of the body with respect to A, and s the radius with respect to B; then

$$r^2 = x^2+y^2+z^2$$
$$s^2 = u^2+y^2+z^2$$

The equations of motion are

$$\frac{d^2x}{dt^2} + \frac{Ax}{r^3} - \frac{Bu}{s^3} = 0$$
$$\frac{d^2y}{dt^2} + \frac{Ay}{r^3} + \frac{By}{s^3} = 0$$
$$\frac{d^2z}{dt^2} + \frac{Az}{r^3} + \frac{Bz}{s^3} = 0$$

If we multiply the first equation by $dx = -du$, the second by dy, the third by dz, add the products and integrate, we find for the velocity

$$V^2 = \frac{2A}{r} + \frac{2B}{s} + \frac{2C}{a}$$

where $\frac{2C}{a}$ is the constant of integration. Since we have two forces and two radii-vectores to deal with, we can find great velocities in this case, and nearly rectilinear motion. **Lagrange** has shown that a third force may be added to the system, and the equations of motion can still be integrated. The third force must act at the center of the line joining A and B, and be proportional to the distance of the body.

The problem of two fixed attracting centers is perhaps an ideal one, but I think it may exist approximately in nature. In the celestial mechanics of the future the great question will be to determine the truth of the Newtonian law of attraction, and for this there will be needed a full and complete development of all the theories of motion.

Harvard University, 1898 *Jan.* 22.

NATURE OF THE VARIATIONS OF *U PEGASI*.

By S. C. CHANDLER.

An examination of my observations shows in the clearest manner that Prof. **Pickering**'s conclusion is correct that they are not affected by systematic subjective error, as I had supposed, and that the observed inequalities arise from an erroneous enumeration of the periods elapsed between the successive dates of observation. But his further conclusion, that the period is nine hours and the light-curve analogous to that of *β Lyrae*, is not borne out by my observations, and also appears to be an overstrained interpretation of Mr. **Wendell**'s photometric observations, as I shall presently show.

From all the data at hand I have found the following elements of the star:

$$\left.\begin{array}{ll}\text{Minimum, 1894 Sept. } 22^{\text{d}} & 15^{\text{h}}\,58^{\text{m}}.3 \\ \text{Maximum,} & 18\ 13\ 2\end{array}\right\}\ \text{Gr. M.T.} + 1^{\text{h}}\,29^{\text{m}}\,50^{\text{s}}.67\,E$$

If we compare these elements with my observed data of minima and maxima given in *A.J.*, XVI, 107 — omitting the two dates in 1894, which are of merely nominal weight, being rude deductions from the isolated estimates by means of which I originally discovered the variability of the star — we have, by separating the even and odd phases,

Even Minima			Odd Minima		
Mag.	O—C	p	Mag.	O—C	p
	m			m	
9.65	+ 8.0	2	9.60	+26.1	1
9.63	+ 4.3	4	9.72	+ 0.7	3
9.55	+14.6	1	9.70	−13.1	5
9.62	+ 7.5	3	9.63	+ 6.8	2
9.63	−17.2	4	9.62	−20.4	3
9.72	−13.4	1	9.68	− 4.9	2
			9.62	+ 0.9	2
9.63	− 0.8		9.65	+ 2.4	

Even Maxima			Odd Maxima		
Mag.	O—C	p	Mag.	O—C	p
	m			m	
8.98	+38.4	3	8.90	+36.7	5
9.02	−30.2	2	8.85	− 0.8	5
9.00	−19.3	1			
9.03	− 8.3	2			
9.00	+ 5.8	3			
9.01	+ 3.3		8.88	+17.9	

The mean values of O – C are $-0^{\mathrm{m}}.8$ and $+2^{\mathrm{m}}.4$ for the even and odd minima, respectively. These observations, then, show no sensible inequality between immediately consecutive periods.

The mean values of the brightness are $9^{\mathrm{M}}.63$ and $9^{\mathrm{M}}.65$ for the even and odd minima, respectively. Therefore, also, these observations show no sensible inequality in the brightness at successive minima.

The intervals of the star's increase and decrease are taken in the elements as exactly equal, being each $2^{\mathrm{h}}\ 14^{\mathrm{m}}.9$. Therefore the above values of O – C for the maxima — having regard to their small number and the greater uncertainty, relatively to the minima, of their determination — show no sensible inequality in the intervals between the principal phases.

The testimony of these observations then is that the period of this star is not 9 hours, with a double light-curve, as found by Prof. Pickering; but is $4^{\mathrm{h}}\ 29^{\mathrm{m}}.8$, with a simple and symmetrical light-curve. I shall presently show that a determination of the light-curve in a more direct manner leads to the same result. But meanwhile I deem it proper to remark that Prof. Pickering's inferences — from the supposed difference of $0^{\mathrm{M}}.15$ in the brightness of alternate minima, which the Harvard College observations appear to exhibit — have hardly a sufficiently trustworthy basis, when it is remembered that observations with the same photometer have heretofore failed to make manifest the secondary minimum of the star *Z Herculis*, a phenomenon involving a difference of nearly $0^{\mathrm{M}}.5$, or three times the amount here in question; notwithstanding the fact that the existence of the secondary phase of *Z Herculis* appears to be satisfactorily established by the concurrent testimony of several good observers. Dunér has recently (*A.J.* 422) sought to explain this strange failure, but manifestly the explanation is insufficient, as will be seen by the following statement; where the first column gives the time of the secondary phase according to Dunér's newest elements, and the second column the range in time covered by the H.C. measures, which gave the star always its maximum brilliancy.

Secondary Minimum				Range of H.C.O. measures		
	d	h m		h m		h m
1895 Sept.	10	15 48.71		13 0	to	15 56
	14	15 38.27		13 51	“	17 35
	30	14 56.51		12 37	“	16 8
Oct.	8	14 35.43		13 35	“	15 40

Assuming the existence of the phenomenon to be well proved, the inability of the H.C. photometric observations to make a difference of $0^{\mathrm{M}}.45$ palpable in the case of *Z Herculis* naturally leads us to be cautious in accepting as real the comparatively nominal difference of $0^{\mathrm{M}}.15$ in the case of *U Pegasi*.

A normal light-curve has been formed from all my observations of 1895, in the usual manner. The odd and even minima were separated, to test the point in question, as shown below.

Odd Periods				Even Periods			
Time	Obs.	Br.	*v*	Time	Obs.	Br.	*v*
m		M	M	m		M	M
–256	3	9.66	+0.06	+ 18	5	9.55	–0.03
249	4	9.56	.00	36	5	9.46	– .03
235	5	9.53	+ .03	53	5	9.42	+ .02
217	5	9.35	– .05	75	5	9.27	– .02
196	5	9.26	– .03	98	5	9.30	+ .11
174	5	9.18	– .01	116	5	9.13	+ .01
156	5	9.04	– .09	142	5	9.19	+ .09
136	5	9.11	+ .02	167	5	9.19	+ .02
118	5	9.15	+ .03	193	5	9.21	– .07
94	5	9.22	+ .02	216	5	9.38	– .01
65	5	9.35	+ .01	236	5	9.56	+ .06
35	5	9.48	– .01	248	5	9.51	– .05
– 4	5	9.60	–0.03	+267	5	9.63	–0.01

It was found that through these 26 observed normal points a curve could be drawn, perfectly symmetrical as respects the increasing and decreasing portions, which would represent the odd and even periods equally well, within reasonable errors of observation. This curve is given below, and the deviations of the observed points from it are inserted above in the columns *v*.

Time from Min.	Brightness	Diff. for 1^{m}
h m	M	M
2 15	9.090	0.0000
2 10	.093	12
2 0	.112	25
1 50	.142	34
1 40	.179	39
1 30	.220	42
1 20	.264	46
1 10	.311	48
1 0	.361	51
0 50	.413	52
0 40	.466	53
0 30	.519	52
0 20	.570	48
0 10	.613	36
0 0	9.640	0.0000

I conclude that for the present, until much more satisfactory evidence is adduced to prove the contrary, *U Pegasi* may be regarded as having a single period of $4^{\mathrm{h}}\ 29^{\mathrm{m}}\ 50^{\mathrm{s}}.67$, and a simple symmetrical light-curve with equal intervals of increase and decrease.

ANNOUNCEMENTS OF VARIABILITY.

Rev. T. E. Espin announces the variability of the following stars:

Esp.-Birm. 649	; (1900) $20^{\mathrm{h}}\ 6^{\mathrm{m}}\ 17^{\mathrm{s}}$,	$+41^{\circ}\ 12'$.	Var. from $8^{\mathrm{M}}.9$ to $10^{\mathrm{M}}.2$.	IVth type spectrum.
Esp. 911	; (1900) 20 29 55 ,	+54 37.	Var. from 9 to 14.	

OBSERVED MAXIMA AND MINIMA OF LONG-PERIOD VARIABLES,

By J. A. Parkhurst.

103. *T Andromedae.*

The season's observations began 1897 May 24, when the star was $10^{M}.5$. It declined regularly to a minimum, $12^{M}.5$, Aug. 16, then rose till, at the time the series was interrupted, Nov. 20, it was $9^{M}.7$. The curve is quite similar to that of the previous minimum, and the correction to the revised elements of *A.J.* 420, is -5 days. The interval since the last minimum, 265 days, agrees with Yendell's elements. I have 16 observations between the above dates.

678. *U Persei.*

The maximum just passed (1897 Nov. 7, at $6^{M}.8$) was half a magnitude brighter than the last two maxima, and about three weeks later than the ephemeris. There was the usual halt in the rise at $8^{M}.2$, lasting nearly through August. The decline after the maximum was more rapid than usual. I have 26 observations since the last minimum. At the last comparison, 1897 Dec. 29, the star was $8^{M}.7$.

4471. *T Canum Venaticorum.**

A minimum at $11^{M}.8$, 1897 Sept. 17, is indicated by 16 observations between Aug. 1 and Dec. 31. The curve harmonizes well with Anderson's estimates in *A.N.* 3433 (May 29, $8^{M}.8$; July 9–10, $<9^{M}.5$), and suggests a period of 9 to 12 months.

5601. *S Ursae minoris.*

The past maximum was quite different from the two preceding. They were characterized by a halt in the rise at $8^{M}.2$ or $8^{M}.3$, followed by a more rapid rise to the maximum at about $7^{M}.3$. This time the rapid rise did not occur, but the curve was very flat, so that the maximum might be located any time from Oct. 1 to Nov. 10, rising nowhere above $7^{M}.8$. The smooth curve gives as the date of maximum 1897 Oct. 24. I have 12 observations up to Dec. 29.

5798. *RU Herculis.*

This star was first seen, about 9^{M}, 1897 Jan. 7, but owing to a mistake in identification it was only observed as a comparison-star May 5, $12^{M}.0$, and July 21, $12^{M}.7$. It was then correctly identified, but remained invisible (below $12^{M}.5$) till Oct. 14, when it was seen at $12^{M}.7$. It rose slowly to $11^{M}.8$ on Nov. 16. A minimum is thus very roughly indicated sometime between Sept. 1 and 20, below $12^{M}.5$.

6207. *Z Ophiuchi.*

The season's observations began 1897 May 5, and ended Nov. 16, there being 22 observations in the interval. The star fell slowly from $8^{M}.7$ to a minimum, Sept. 15, at $11^{M}.8$, then rose slightly faster to $9^{M}.3$ at the last observation. The minimum was more sharply defined than that of 1896, about equally so with that of 1895. The observations are not consistent with a minimum any earlier than the above date, but would allow it to be 5 or 6 days later.

6549. *W Lyrae.*

I have watched this star continuously since the minimum recorded in *A.J.* 412, securing 21 observations up to Dec. 29. It rose quickly and steadily to a well-defined maximum, $8^{M}.1$, 1897 Oct. 23, then fell almost as quickly till it was $10^{M}.9$ on Dec. 29.

6871. *V Lyrae.*

This star passed a faint maximum, $10^{M}.2$, 1897 Oct. 27. It was fainter than $12^{M}.6$ from May 25 to Aug. 27, when first seen; and at the last comparison, Nov. 20, had fallen to $10^{M}.9$. I have 15 observations.

7085. *RT Cygni.*

I have 32 observations of this star since the minimum recorded in *A.J.* 412. It rose rapidly to a maximum, $7^{M}.2$, 1897 Aug. 10, then fell to the faintest minimum I have ever seen, reaching $12^{M}.5$ on Nov. 23. Unfortunately the series was then interrupted till Dec. 29, when it had risen to $8^{M}.9$, so that the precise date of minimum can not be determined from these observations; but a comparison with curves for previous minima shows that it probably occurred between Nov. 16 and 26, at about $12^{M}.5$.

7792. *SS Cygni.*

A new reduction of my June and July observations, with improved magnitudes of the comparison-stars, leads me to think that the reported slow fall "from $11^{M}.0$, June 20, to $11^{M}.2$, Aug. 6" (*A.J.* 412), was probably illusory, and that the star at normal brightness remains constant at about $11^{M}.3$. Since the report in the above number I have 66 observations covering every clear night up to Nov. 23. The star remained constant at $11^{M}.3$ from Aug. 20 to Sept. 26, after which a rise occurred as follows:

	M		M
Sept. 26.54	11.3	Sept. 30.94	8.48
27.59	10.75	Oct. 1.52	8.56
27.94	9.80	2.55	8.62
28.53	8.86	3.54	8.52
29.59	8.70	4.53	8.65
30.52	8.56	5.52	8.77

These observations yield a maximum at $8^{M}.5$, 1897 Oct. 2.5, after which the decline was steady, reaching normal magnitude Oct. 18, and remaining so till the last observation.

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*See *A.J.* 424, p. 128.

8324. *V Cassiopeae.*

Since the minimum reported in *A.J.* 412 I have 32 observations, yielding a well-defined maximum, 7ᴹ.3, 1897 Sept. 13. The correction to my elements (*A.J.* 358) is +1 day, to those of the Third Catalogue, +11 days. The fall after maximum was steady as usual till at the last observation, 1898 Jan. 16, it was about at its minimum magnitude.

OBSERVATIONS OF *TETHYS* AND *RHEA*,

MADE WITH THE 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

By E. O. LOVETT.

In the following measures, the angles given are each the mean of two comparisons; the distances were obtained from measures of double distances. Corrections have been applied for refraction. Eastern mean time is used (75th meridian).

1894	Eastern Time h m s	*p* °	Eastern Time h m s	*s* ″
Mar. 5	16 44 3	330.91	. . .	. .
6	16 35 7	89.46	. . .	. .
8	12 54 38	268.49	13 29 31	36.35
	. . .	. .	13 31 56	36.23
	. . .	. .	13 47 25	36.17
12	16 47 35	229.78	17 25 44	39.37
	17 55 42	237.09	17 28 8	40.58
	. . .	. .	18 11 16	46.38
	. . .	. .	18 13 28	45.65
13	16 48 1	281.81	17 19 39	88.14
	17 49 54	284.01	17 24 57	89.55
14	16 19 33	80.48	. . .	. .
15	12 27 24	79.09	. . .	. .
18	12 32 54	277.42	12 51 46	35.66
	13 7 41	278.45	12 54 47	35.92
21	16 59 45	246.00	17 12 47	19.85
	17 23 55	244.68	17 51 8	20.29
22	16 51 12	271.50	. . .	. .
23	15 34 6	70.15	. . .	. .
26	14 31 44	266.30	15 50 35	128.23
	15 43 52	267.63	15 55 52	128.32
30	14 17 55	262.65	14 33 16	80.14
	. . .	. .	14 41 2	80.31
Apr. 2	13 42 49	94.04	13 46 15	100.89
	13 53 10	95.09	13 48 39	100.81
4	12 28 19	252.51	12 32 16	78.09
	12 38 55	252.67	12 35 14	78.01
15	9 57 24	79.27	10 1 1	96.46
	10 8 59	79.32	10 4 48	96.14
	12 11 23	82.21	12 15 38	100.88
	12 19 53	82.52	12 17 33	100.98
17	12 16 32	166.48	12 20 16	24.90
	12 25 00	169.45	12 21 58	24.79
19	9 38 38	62.61	9 44 17	25.84
	9 52 29	62.92	9 46 45	25.74
24	14 26 56	76.52	14 33 18	*95.72
	14 47 18	76.71	14 35 45	*95.63
25	14 40 39	119.41	14 44 55	32.60
	14 53 33	120.53	14 46 43	32.40
26	10 21 2	140.99	10 24 31	10.65
	10 29 12	140.94	10 26 32	10.60
	13 29 41	149.07	13 32 36	12.15
	13 38 51	149.01	13 35 40	12.26
27	15 31 18	270.10	15 35 3	125.64
	15 43 44	270.65	15 39 1	125.48
28	11 14 26	52.42	11 19 24	42.10
	11 30 7	55.13	11 23 37	42.16
Apr. 29	8 28 20	87.56	8 31 12	40.74
	8 35 45	87.53	8 32 50	10.56
	9 35 34	87.45	9 38 20	38.52
	9 43 10	87.05	9 40 13	38.50
May 1	13 3 46	266.11	13 7 37	118.27
	13 13 47	265.94	13 10 27	118.31
	15 3 39	267.73	15 6 21	117.21
2	8 22 3	295.68	8 25 5	24.21
	8 28 18	295.22	8 26 37	24.20
	11 39 3	302.92	11 40 50	17.18
	11 44 25	303.15	11 42 32	17.23
	13 29 15	303.10	13 31 44	14.35
	13 36 14	303.27	13 33 34	14.38
3	11 42 48	18.69	11 45 59	20.27
	11 51 41	20.46	11 48 31	20.38
	12 53 37	36.66	12 55 52	25.69
	13 0 8	37.53	12 57 45	25.66
9	13 0 14	96.40	13 3 26	41.90
	13 7 53	96.75	13 5 12	11.86
10	13 40 57	257.72	13 43 34	96.52
	13 48 47	258.31	13 45 44	96.47
12	9 26 55	73.80	9 29 4	23.07
	9 32 9	73.23	9 30 30	22.96
	11 9 48	71.09	11 12 48	20.40
	11 18 9	71.51	11 15 4	20.39
13	12 32 16	88.87	12 34 57	111.70
	12 40 44	88.95	12 36 47	111.65
16	11 23 4	281.99	11 25 26	59.53
	11 30 31	282.33	11 27 56	59.42
17	12 29 7	86.30	12 31 25	125.10
	12 36 11	86.61	12 33 22	125.08
	13 51 22	87.83	13 54 16	125.15
	13 58 40	88.07	13 56 38	125.24
21	8 54 56	78.36	8 57 31	74.27
	9 1 53	78.59	9 0 30	74.25
29	12 33 16	270.73	12 35 34	92.98
	12 40 1	270.46	12 37 39	93.01
June 2	11 58 51	266.57	12 2 35	125.11
	12 5 45	266.77	12 3 17	125.31
7	10 37 7	93.87	10 39 19	31.14
	10 42 58	93.78	10 41 19	31.13
	11 59 27	92.80	12 1 49	32.44
	12 6 6	92.70	12 3 29	32.52
10	9 15 22	224.79	9 20 51	6.75
	9 27 54	225.58	9 24 55	6.86
11	10 49 17	258.68	10 52 17	71.61
	10 55 53	258.83	10 53 10	71.58
15	12 22 7	256.19	12 27 4	90.28
	12 33 24	256.17	12 28 9	90.33
24	8 30 26	172.72	8 32 50	17.09
	8 37 30	174.78	8 34 33	17.06
	10 49 44	214.99	10 54 4	23.84
	10 59 1	215.69	10 56 12	23.80

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* Single distances.

TRAJECTORY OF THE POLE FOR COMPUTING LATITUDE-VARIATIONS IN 1898,

By S. C. CHANDLER.

The following tables for finding variations of latitude in 1898 are a continuation of those given in *A.J.*, XVII, 63, and are constructed on the same formulas used for several years past.

Coordinates of the Pole for 1898.

1898	Rectangular		Polar	
	x	y	r	a
	″	″	″	
Jan. 19	−0.042	+0.182	0.187	347.0
Feb. 8	+0.035	.217	.220	9.2
28	.109	.232	.256	25.2
Mar. 20	.170	.221	.279	37.6
Apr. 9	.213	.188	.284	18.6
29	.234	.135	.270	60.0
May 19	.232	+0.070	.242	73.2
June 8	.205	−0.005	.205	91.4
28	.159	.080	.178	116.7
July 18	.098	.147	.177	146.3
Aug. 7	+0.028	.198	.200	172.0
27	−0.011	.233	.237	190.7
Sept. 16	.109	.242	.265	204.2
Oct. 6	.162	.226	.278	215.6
26	.199	.187	.273	226.8
Nov. 15	.213	.131	.250	238.4
Dec. 5	.207	−0.061	.216	253.6
25	.179	+0.016	.180	275.1
45	−0.135	+0.090	0.162	303.7

$$\varphi - \varphi_0 = x \sin \lambda - y \cos \lambda = -r \cos (a + \lambda)$$

The variations of latitude for four principal meridians are given below, computed from the foregoing table and formulas.

Variations of Latitude in 1898, $\varphi - \varphi_0$.

1898	Pulkowa	Berlin	Paris	Washington
	″	″	″	″
Jan. 19	−0.136	−0.168	−0.180	−0.082
Feb. 8	.205	.219	.218	−0.015
28	.255	.251	.236	+0.054
Mar. 20	.277	.254	.228	.116
Apr. 9	.270	.232	.197	.165
29	.235	.185	.144	.198
May 19	.178	.122	.079	.211
June 8	.099	−0.012	−0.003	.201
28	−0.011	+0.041	+0.073	.173
July 18	+0.078	.120	.143	.129
Aug. 7	.157	.186	.197	.072
27	.224	.237	.235	+0.010
Sept. 16	.264	.261	.246	−0.052
Oct. 6	.277	.257	.232	.107
26	.262	.228	.195	.152
Nov. 15	.221	.177	.140	.178
Dec. 5	.157	.107	+0.070	.188
25	+0.077	+0.026	−0.009	.178
45	−0.010	−0.056	−0.084	−0.152

For Greenwich take simply y with the opposite sign.

It may be appropriate to add in this place that we now have conclusive proof, absolutely independent of the evidence in *A.J.* 322, of the progressive diminution during the past few years of both the period and the radius of the 428^d-term, as required by the announced law of the variation of the coefficients of that term. While awaiting fuller publication of the results of observations 1896–98, I take this opportunity to state briefly the nature of this proof, already alluded to in *A.J.* 392.

The discussion of the principal series of observations by TALCOTT's method, 1889 to 1896, gives the following values of the radius, r_1, of the fourteen-months' term.

	Observed	Eq. (52)		Observed	Eq. (52)
	″	″		″	″
1890.0	0.201	0.170	1893.6	0.130	0.157
1891.2	0.175	0.166	1894.7	0.123	0.152
1892.4	0.199	0.162	1895.9	0.114	0.146

Again, from the four series of observations in the following table, none of which were used in the determination of the law in question, we have in the second column the observed Greenwich date of minimum latitude, T_1, by this term. The fourth column contains the resulting observed periods; and the fifth column the periods computed from the law developed in *A.J.* 322.

		T_1	Obs'd	Eq. (52)
Ivanoff-Peters, Pulk. Vert. Circle,	1842–49	239 4914	433.5	431.6
Nyrén, " " "	1882–89	240 9654	428.3	425.7
Gonnessiat, Lyons Mer. Circle,	1885–93	241 0939	426.3	424.0
Various series, Talcott's method,	1889–96	241 2217		

In addition, the data of the last series, (1889–96), discussed by themselves, yield the value 425^d.8.

From these comparisons it would seem that there can no longer be any reasonable doubt that this element of the polar motion is varying, both in dimension and velocity, substantially in the manner indicated by the entirely independent series of observations from 1825 to 1890, employed in the investigation referred to.

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OBSERVATIONS OF DOUBLE STARS.

By WILLIAM J. HUSSEY.

The following list of double stars is composed largely of well-known binaries and of pairs in which there has been more or less motion. In a few cases, however, the stars are relatively fixed. Some of the stars are close and difficult, and in about half the cases the distances are under $\frac{3}{4}''$.

The observations have been made with the 12-inch and 36-inch refractors of the Lick Observatory. An eyepiece magnifying, nominally, 700 diameters has been employed in making all the observations with the former instrument, and no measures with it have been attempted when the seeing was not good enough to bear this power. The powers generally used with the large telescope were 1000 and 1500; higher powers were occasionally used for very close stars, and a power of 520 for a few wide ones.

In nearly all cases each position-angle is derived from the mean of four independent settings of the circle, and each distance from three double distances. The exceptions to this are a few cases of close or otherwise difficult stars for which one or more additional settings were sometimes made.

The positions of the stars are for the epoch 1900. The aperture of the telescope used in making the observations is given in the last column.

Σ 3062.

$\alpha = 0^{h}\ 1^{m}\ 2^{s}$; $\delta = +57^{\circ}\ 52'.7$

	°	″	
1897.825	338.1	1.44	12
.830	336.1	1.52	12
.833	339.3	1.45	12
.868	335.7	1.68	12
1897.84	337.4	1.52	

Σ 24.

$\alpha = 0^{h}\ 13^{m}\ 19^{s}$; $\delta = +25^{\circ}\ 35'.1$

1897.721	246.3	5.32	36
.762	248.6	5.10	36
1897.74	247.5	5.21	

No change.

β 395.

$\alpha = 0^{h}\ 32^{m}\ 12^{s}$; $\delta = -25^{\circ}\ 19'.0$

1897.910	277.1	0.32	36
.913	274.5	0.26	36
.932	273.8	0.34	36
1897.92	275.1	0.31	

Binary. Rapid change since 1891.

η *Cassiopeae.*

$\alpha = 0^{h}\ 43^{m}\ 3^{s}$; $\delta = +57^{\circ}\ 17'.1$

1897.644	212.6	5.16	36
.682	209.4	5.06	36
.762	212.3	5.08	36
.830	211.9	5.26	12
.833	211.3	5.22	12
1897.75	211.5	5.16	

Σ 73 = 36 *Andromedae.*

$\alpha = 0^{h}\ 49^{m}\ 37^{s}$; $\delta = +23^{\circ}\ 5'.2$

	°	″	
1897.721	16.3	1.22	36
.762	16.7	1.16	36
.778	15.2	1.16	36
.825	17.1	0.97	12
.868	18.5	1.29	12
1897.79	16.8	1.16	

β 1028 = γ *Cassiopeae.*

$\alpha = 0^{h}\ 50^{m}\ 40^{s}$; $\delta = +60^{\circ}\ 10'.5$

1897.664	254.5	2.09	36
.989	255.8	2.11	36
1897.83	255.2	2.10	

No change in angle or distance since first measured by BURNHAM in 1888.

OΣ 515 = *q Andromedae.*

$\alpha = 1^{h}\ 3^{m}\ 42^{s}$: $\delta = +46^{\circ}\ 42'.5$

1897.625(1)	58.0	0.34	36
.950	243.7	0.24	36
.989	61.6	0.24	36
1897.85	61.1	0.27	

(1) Estimated distance 0″.20.

h 2036.

$\alpha = 1^{h}\ 15^{m}\ 3^{s}$: $\delta = -16^{\circ}\ 20'.2$

1897.926	16.5	1.51	12
.948	17.4	1.36	12
1897.94	17.0	1.44	

The angle has decreased 36° since 1830.

γ *Andromedae.*

$\alpha = 1^{h}\ 57^{m}\ 56^{s}$; $\delta = +41^{\circ}\ 51'.0$

A and *BC*.

	°	″	
1897.721	63.2	10.44	36
.762	63.3	10.36	36
1897.74	63.2	10.40	

BC = *O*Σ 38.

1897.950	120.7	0.31	36
.989	114.8	0.27	36
1897.97	117.8	0.29	

Σ 227 = *i Trianguli.*

$\alpha = 2^{h}\ 6^{m}\ 34^{s}$: $\delta = +29^{\circ}\ 50'.1$

1897.721	74.9	4.08	12
.740	75.9	3.74	12
1897.73	75.4	3.91	

Σ 228.

$\alpha = 2^{h}\ 7^{m}\ 38^{s}$; $\delta = +47^{\circ}\ 1'.1$

1897.721	257.5	0.53	36
.762	256.4	0.55	36
.778	260.0	0.62	36
1897.75	258.0	0.57	

Σ 412. 7 *Tauri.*

$\alpha = 3^{h}\ 28^{m}\ 31^{s}$; $\delta = +24^{\circ}\ 7'.7$

1897.995	192.9	0.23	36

β 533.

$\alpha = 3^{h}\ 29^{m}\ 24^{s}$; $\delta = +31^{\circ}\ 20'.8$

1897.995	230.2	0.60	36

OΣ 65.

$\alpha = 3^h\ 44^m\ 18^s\ ;\ \delta = +25^\circ\ 16'.7$

	°	″	
1897.910	203.7	0.56	12
.913	203.9	0.61	36
1897.91	203.8	0.59	

OΣ 74.

$\alpha = 4^h\ 6^m\ 49^s\ ;\ \delta = +9^\circ\ 23'.5$

1897.950	294.3	0.38	36
.989	293.3	0.36	36
.995	293.6	0.32	36
1897.98	293.7	0.35	

β 552.

$\alpha = 4^h\ 46^m\ 11^s\ ;\ \delta = +13^\circ\ 29'.2$

1897.913	193.7	0.49	36
.950	192.2	0.45	36
.989	194.2	0.36	36
1897.95	193.4	0.43	

Rapid binary.

OΣ 82.

$\alpha = 4^h\ 17^m\ 4^s\ ;\ \delta = +14^\circ\ 49'.3$

1897.910	136.8	0.72	12
.913	134.0	0.74	36
.926	132.0	0.57	12
1897.92	134.3	0.68	

β 883.

$\alpha = 4^h\ 45^m\ 40^s\ ;\ \delta = +10^\circ\ 53'.8$

1897.913	212.8	0.33	36
.950	215.0	0.26	36
.989	216.5	0.22	36
1897.95	214.8	0.27	

Rapid binary.

OΣ 98 = 14 *Orionis.*

$\alpha = 5^h\ 2^m\ 26^s\ ;\ \delta = +8^\circ\ 22'.1$

1897.868	182.3	1.16	12
.777	185.8	0.96	12
.885	183.1	1.02	12
1897.88	183.7	1.05	

Σ 728.

$\alpha = 5^h\ 25^m\ 26^s\ ;\ \delta = +5^\circ\ 52'.3$

1897.950(1)	154.8	0.21	36
.989	168.2	0.24	36
1897.97	161.5	0.22	

(1) Estimated distance 0″.15. Not separated.

Σ 749.

$\alpha = 5^h\ 30^m\ 54^s\ ;\ \delta = +26^\circ\ 51'.7$

1897.961	188.6	0.97	12
.975(1)	188.0	0.89	12
.978	188.0	0.89	12
1897.97	188.2	0.92	

(1) Brighter star certainly north.

OΣ 112.

$\alpha = 5^h\ 33^m\ 3^s\ ;\ \delta = +37^\circ\ 54'.1$

	°	″	
1897.961	70.8	0.77	12
.975	72.7	0.69	12
.978	74.3	0.79	12
1897.97	72.6	0.75	

OΣ 115.

$\alpha = 5^h\ 38^m\ 48^s\ ;\ \delta = +15^\circ\ 1'.2$

1897.961	121.9	0.74	12
.975	118.5	0.74	12
.978	118.2	0.67	12
1897.97	119.5	0.72	

OΣ 119.

$\alpha = 5^h\ 42^m\ 29^s\ ;\ \delta = +7^\circ\ 55'.5$

1897.961	321.9	0.64	12
.971	327.6	0.73	12
.978	323.1	0.70	12
1897.97	324.2	0.69	

Σ 881.

$\alpha = 6^h\ 13^m\ 11^s\ ;\ \delta = +59^\circ\ 24'.9$

1897.992	104.6	0.87	12
.995	104.4	0.92	36
1897.99	104.5	0.90	

OΣ 149.

$\alpha = 6^h\ 30^m\ 11^s\ ;\ \delta = +27^\circ\ 21'.7$

1897.910	278.0	0.82	12
.926	279.8	0.82	12
.950	279.6	0.58	36
.975	276.0	0.80	12
1897.94	278.4	0.75	

Angular motion about 70° since 1848.

Σ 935.

$\alpha = 6^h\ 30^m\ 34^s\ ;\ \delta = +52^\circ\ 22'.8$

1897.992	322.8	3.24	12
.995	322.8	3.53	36
1897.99	322.8	3.38	

No change.

Σ 945.

$\alpha = 6^h\ 33^m\ 20^s\ ;\ \delta = +41^\circ\ 3'.5$

1897.992	266.0	0.85	12
.995	269.7	0.78	36
1897.99	267.8	0.81	

Σ 948 = 12 *Lyncis.*

$\alpha = 6^h\ 37^m\ 24^s\ ;\ \delta = +59^\circ\ 32'.6$

AB.

1897.868	121.1	1.58	12
.877	120.3	1.57	12
.885	119.3	1.57	12
.910	119.2	1.52	12
1897.89	120.0	1.56	

AC.

1897.868	306.2	8.62	12

AC unchanged.

Sirius.

$\alpha = 6^h\ 40^m\ 44^s\ ;\ \delta = -16^\circ\ 34'.7$

	°	″	
1897.206	186.6	3.78	36
1897.835	175.4	. .	36
.989	174.7	3.98	36
.995	175.0	4.04	36
1897.21	186.6	3.78	
1897.94	175.0	4.01	

A power of 520 was used in making the first and second observations, and one of 1000 for the third and fourth. The results for 1897.989 were derived from ten settings of the micrometer, giving 174°.67 ± 0°.13 and 3″.98 ± 0″.02. At the time this observation was made the seeing was excellent, and there was no wind. The companion was seen with great distinctness, and the individual settings of the micrometer could be made with the same degree of accuracy as for any other double star of this distance.

OΣ 156.

$\alpha = 6^h\ 41^m\ 33^s\ ;\ \delta = +18^\circ\ 18'.1$

1897.992	301.7	0.67	12
.995	305.7	0.64	36
1897.99	303.7	0.65	

Σ 963 = 14 *Lyncis.*

$\alpha = 6^h\ 44^m\ 16^s\ ;\ \delta = +59^\circ\ 34'.0$

1897.877	72.8	0.54	12
.885	75.2	0.45	12
.910	74.3	0.50	12
1897.89	74.1	0.50	

Σ 1037.

$\alpha = 7^h\ 6^m\ 36^s\ ;\ \delta = +27^\circ\ 23'.7$

1897.910	301.3	0.90	12
.926	304.1	0.99	12
.975	304.1	0.97	12
1897.94	303.2	0.95	

Σ 1074.

$\alpha = 7^h\ 15^m\ 23^s\ ;\ \delta = +0^\circ\ 35'.4$

1897.992	140.6	0.70	12
.995	143.7	0.63	36
1897.99	142.2	0.66	

Castor.

$\alpha = 7^h\ 28^m\ 13^s\ ;\ \delta = +32^\circ\ 6'.5$

1897.910	226.5	5.64	12
.926	226.9	5.76	12
.950	227.8	5.76	36
1897.93	227.1	5.72	

Procyon.

$\alpha = 7^h\ 34^m\ 7^s\ ;\ \delta = +5^\circ\ 28'.9$

1897.072	319.2	4.58	36
.203	320.1	4.77	36
.206	320.0	4.59	36
1897.16	319.8	4.65	

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β 101 = 9 *Argus.*

$\alpha = 7^h\ 47^m\ 18^s$; $\delta = -13^\circ\ 38'.0$

	°	″	
1897.926	294.4	0.62	12
.950	287.6	0.62	36
.975	296.6	0.60	12
1897.95	292.9	0.61	

Σ 1187 = 85 *Lyncis.*

$\alpha = 8^h\ 3^m\ 11^s$; $\delta = +32^\circ\ 30'.8$

1897.910	45.8	1.96	12
.926	44.8	2.13	12
1897.92	45.3	2.05	

Σ 1196 = ζ *Cancri.*

$\alpha = 8^h\ 6^m\ 29^s$; $\delta = +17^\circ\ 57'.0$

AB.

1897.066	17.6	0.97	12
.206(1)	21.6	0.98	36
.222	15.3	1.01	36
.340	15.2	1.04	36
1897.877	11.0	1.06	12
.885	12.8	1.14	12
.904	12.2	1.19	12
1897.21	17.4	1.00	
1897.89	12.0	1.13	

AC.

1897.066	117.5	5.22	12
.206(1)	116.3	5 26	36
.223	116.7	5.26	36
.877	117.7	5.31	12
.885	116.5	5.53	12
.904	116.8	5.50	12
1897.53	116.9	5.35	

(1) Wind swaying telescope.

Σ 1216.

$\alpha = 8^h\ 16^m\ 16^s$; $\delta = -1^\circ\ 17'.0$

1897.926	189.8	0.54	12
.950	190.9	0.47	36
.975	197.4	0.52	12
1897.95	192.7	0.51	

Σ 3121.

$\alpha = 9^h\ 11^m\ 57^s$; $\delta = +28^\circ\ 59'.8$

1897.910	14.7	0.72	12
.926	15.2	0.75	12
.975	17.5	0.78	12
1897.94	15.8	0.75	

ω *Leonis.*

$\alpha = 9^h\ 23^m\ 6^s$; $\delta = +9^\circ\ 29'.5$

1897.066	109.4	0.91	12
.072	110.3	0.90	36
.206	109.9	0.83	36
.223	111.0	0.88	36
.877	109.8	0.82	12
.907	113.8	0.99	12
.910	112.6	0.84	12
1897.47	111.0	0.88	

*O*Σ 208 = *q Ursae Majoris.*

$\alpha = 9^h\ 45^m\ 18^s$; $\delta = +54^\circ\ 31'.9$

	°	″	
1897.877	267.3	<0.40 est.	12
.885	271.7	<0.40 est.	12
.910	271.3	0.34	12
1897.89	271.1	0.34	

*O*Σ 215.

$\alpha = 10^h\ 10^m\ 49^s$; $\delta = +18^\circ\ 14'.3$

1897.877	211.2	0.84	12
.910	210.1	0.93	12
.926	210.0	0.67	12
1897.90	210.5	0.81	

γ *Leonis.*

$\alpha = 10^h\ 14^m\ 28^s$; $\delta = +20^\circ\ 20'.8$

1897.877	115.9	3.97	12
.907	114.4	3.87	12
.910	114.4	3.73	12
1897.90	114.9	3.86	

Σ 1426.

$\alpha = 10^h\ 15^m\ 18^s$; $\delta = +6^\circ\ 56'.0$

AB.

1897.072	281.8	0.97	36
.223	281.7	0.81	36
1897.15	281.8	0.89	

AC.

1897.072	7.0	7.54	36
.223	7.8	7.78	36
1897.15	7.4	7.66	

*O*Σ 224.

$\alpha = 10^h\ 34^m\ 28^s$; $\delta = +9^\circ\ 21'.8$

1897.072	308.0	0.59	36
.223	304.1	0.53	36
1897.15	306.0	0.56	

*O*Σ 227.

$\alpha = 10^h\ 36^m\ 25^s$; $\delta = +11^\circ\ 15'.7$

1897.072	343.3	0.71	36
.223	346.2	0.60	36
.907	347.3	0.61	12
1897.40	345.6	0.67	

ξ *Ursae Majoris.*

$\alpha = 11^h\ 12^m\ 51^s$; $\delta = +32^\circ\ 5'.5$

1897.066	164.4	2.03	12
.877	161.9	1.94	12
.907	161.9	1.99	12
.910	162.5	1.88	12
1897.69	162.7	1.96	

Σ 1536 = ι *Leonis.*

$\alpha = 11^h\ 18^m\ 43^s$; $\delta = +11^\circ\ 4'.8$

1897.072	58.6	2.84	36
.877	57.7	2.57	12
.907	56.8	2.53	12
.910	56.8	2.33	12
1897.69	57.5	2.57	

*O*Σ 234.

$\alpha = 11^h\ 25^m\ 25^s$; $\delta = +41^\circ\ 50'.5$

	°	″	
1897.072	308.7	0.38	36
.877	296.3	0.40	12
.910	302.3	0.35	12
1897.62	302.1	0.38	

*O*Σ 235.

$\alpha = 11^h\ 26^m\ 41^s$; $\delta = +61^\circ\ 38'.2$

1897.877	109.9	0.70	12
.910	102.8	0.79	12
.926	105.5	. .	12
1897.90	106.1	0.75	

Σ 1555.

$\alpha = 11^h\ 31^m\ 2^s$; $\delta = +28^\circ\ 20'.0$

1897.877	344.9	0.51	12
.910	347.9	0.41	12
.926	348.3	0.49	12
.989	345.9	0.47	36
1897.92	346.8	0.48	

Σ 1687 = 35 *Comae Berenices.*

$\alpha = 12^h\ 48^m\ 22^s$; $\delta = +21^\circ\ 47'.3$

1897.877	82.1	1.15	12
.910	79.4	1.24	12
.975	80.5	1.21	12
1897.92	80.7	1.20	

Σ 1728 = 42 *Comae Berenices.*

$\alpha = 13^h\ 5^m\ 7^s$; $\delta = +18^\circ\ 3'.5$

1897.99	200.0	0.11	36

Power, 2900. Elongated.

Σ 1937 = η *Coronae Borealis.*

$\alpha = 15^h\ 19^m\ 4^s$; $\delta = +30^\circ\ 38'.9$

1897.989	238.3	0.46	36
.995	239.7	0.60	36
1897.99	239.0	0.53	

Σ 1967 = γ *Coronae Borealis.*

$\alpha = 15^h\ 38^m\ 33^s$; $\delta = +26^\circ\ 36'.7$

1897.989	120.2	0.53	36
.995	119.1	0.60	36
1897.99	119.7	0.57	

Σ 2026 = σ *Coronae Borealis.*

$\alpha = 16^h\ 10^m\ 56^s$; $\delta = +34^\circ\ 6'.7$

1897.989	211.2	4.45	36
.995	211.8	4.45	36
1897.99	211.5	4.45	

Σ 2272 = 70 *Ophiuchi.*

$\alpha = 18^h\ 0^m\ 24^s$; $\delta = +2^\circ\ 31'.4$

1897.433	282.1	2.13	36
.491	281.6	2.25	36
.510	281.0	2.06	36
.644	279.8	1.96	36
.664	279.6	2.08	36
.860	280.1	1.98	12
.863	279.5	2.04	12
.885	279.2	1.90	12
1897.67	280.4	2.05	

OΣ342 = 72 *Ophiuchi.*

$\alpha = 18^h\ 2^m\ 36^s$; $\delta = +9^\circ\ 33'.0$

1897.64 No indication of duplicity. 36

Σ2281 = 73 *Ophiuchi.*

$\alpha = 18^h\ 4^m\ 36^s$; $\delta = +3^\circ\ 58'.6$

	°	″	
1897.64	231.8	0.38	36

Σ2294.

$\alpha = 18^h\ 9^m\ 27^s$; $\delta = +0^\circ\ 8'.9$

1897.64	105.5	0.20	36

Σ2509.

$\alpha = 19^h\ 15^m\ 54^s$; $\delta = +63^\circ\ 1'.6$

1897.877	338.4	0.91	12
.885	338.4	1.14	12
.926	336.6	0.93	12
1897.89	337.8	0.99	

Σ2579 = δ *Cygni.*

$\alpha = 19^h\ 41^m\ 51^s$; $\delta = +44^\circ\ 53'.2$

1897.644	303.8	1.68	36
.830	306.3	1.55	12
.833	303.1	1.58	12
.835	301.4	1.70	36
.860	299.7	1.81	12
1897.80	302.9	1.66	

Σ2583.

$\alpha = 19^h\ 43^m\ 59^s$; $\delta = +11^\circ\ 34''.0$

1897.860	118.4	1.49	12
.885	117.9	1.51	12
.926	115.3	1.32	12
1897.89	117.2	1.44	

Σ2596.

$\alpha = 19^h\ 49^m\ 27^s$; $\delta = +15^\circ\ 1'.9$

1897.860	329.9	2.06	12
.885	330.4	2.11	12
.926	329.4	1.88	12
1897.89	329.9	2.02	

A.C. 16.

$\alpha = 19^h\ 53^m\ 47^s$; $\delta = +26^\circ\ 59'.0$

1897.885	56.6	0.52	12
.926	65.9	0.35	12
.978	63.2	0.56	12
1897.93	61.9	0.48	

β *Delphini.*

$\alpha = 20^h\ 32^m\ 52^s$; $\delta = +14^\circ\ 14'.8$

	°	″	
1897.433	355.6	0.78	36
.625	357.2	0.75	36
.644	357.7	0.63	36
.721	358.5	0.68	36
1897.61	357.3	0.71	

OΣ413 = λ *Cygni.*

$\alpha = 20^h\ 43^m\ 31^s$; $\delta = +36^\circ\ 7'.4$

1897.835	67.4	0.61	36
.868	63.0	0.75	12
.877	63.7	0.63	12
1897.86	64.7	0.68	

OΣ535 = δ *Equulei.*

$\alpha = 21^h\ 9^m\ 37^s$; $\delta = +9^\circ\ 36'.1$

1897.721	208.5	0.44	36
.778	208.8	0.41	36
.835	207.8	0.36	36
1897.78	208.4	0.40	

τ *Cygni.*

$\alpha = 21^h\ 10^m\ 48^s$; $\delta = +37^\circ\ 37'.1$

1897.664	330.5	0.83	36
.830	330.7	0.55	12
.833	328.3	0.57	12
.835	324.0	0.89	36
.877	328.9	0.78	12
1897.81	328.5	0.72	

A.C. 19.

$\alpha = 21^h\ 11^m\ 39^s$; $\delta = +63^\circ\ 59'.6$

1897.877	254.4	0.84	12
.885	257.2	0.62	12
.904	255.2	0.62	12
1897.89	255.6	0.69	

Σ2799 = 20 *Pegasi.*

$\alpha = 21^h\ 24^m\ 1^s$; $\delta = +10^\circ\ 38'.9$

1897.877	121.2	1.35	12
.885	121.1	1.53	12
.901	121.2	1.39	12
1897.89	121.2	1.42	

β475.

$\alpha = 22^h\ 7^m\ 19^s$; $\delta = -8^\circ\ 30'.4$

1897.860	228.6	1.60	12
.885	228.8	1.48	12
.926	229.6	1.31	12
1897.89	229.0	1.46	

β172.

$\alpha = 22^h\ 18^m\ 54^s$; $\delta = -5^\circ\ 20'.6$

	°	″	
1897.860	7.6	0.72	12
.885	11.8	0.64	12
.904	11.8	0.65	12
1897.88	10.4	0.67	

Σ2909 = ζ *Aquarii.*

$\alpha = 22^h\ 23^m\ 41^s$; $\delta = -0^\circ\ 31'.9$

1897.682	321.4	3.30	36
.762	321.9	3.32	36
1897.72	321.7	3.31	

Σ2915.

$\alpha = 22^h\ 27^m\ 33^s$; $\delta = +6^\circ\ 54'.1$

1897.682	146.8	12.61	36
.762	150.7	12.66	36
1897.72	148.7	12.63	

OΣ477.

$\alpha = 22^h\ 39^m\ 8^s$; $\delta = +45^\circ\ 30'.1$

1897.682	190.6	4.62	36
.835	194.9	4.55	36
1897.76	192.7	4.58	

Ho. 300 = 66 *Pegasi.*

$\alpha = 23^h\ 18^m\ 2^s$; $\delta = +11^\circ\ 45'.9$

1897.63 No evidence of duplicity 36

OΣ495.

$\alpha = 23^h\ 19^m\ 35^s$; $\delta = +56^\circ\ 59'.2$

1897.682	123.9	0.35	36
.885	128.4	0.28	12
.935	122.6	0.34	36
1897.83	125.0	0.32	

β720 = 72 *Pegasi.*

$\alpha = 23^h\ 28^m\ 59^s$; $\delta = +30^\circ\ 46'.4$

1897.625	336.4	0.42	36
.932	339.2	0.39	36
.935	339.5	0.41	36
1897.83	338.4	0.41	

85 *Pegasi.*

$\alpha = 23^h\ 56^m\ 57^s$; $\delta = +26^\circ\ 33'.2$

1897.625	210.5	0.66	36
.664	208.9	0.80	36
.721	208.3	0.79	36
.989	211.8	0.66	36
1897.75	209.9	0.74	

Lick Observatory, University of California, Mt. Hamilton, 1897 *Dec.* 13.

REQUEST FOR UNPUBLISHED OBSERVATIONS OF *ALGOL.*

Mr. A. PANNEKOEK, of the Leyden Observatory, requests that any unpublished observations of the brightness of *Algol* be sent him, for use in a discussion of its variability.

THE ABERRATION-CONSTANT OF THE FRENCH CONFERENCE,

By S. C. Chandler.

The desirability, indeed the pressing need, of a common system of clock-stars for general use has long been recognized. As succinctly stated by Prof. Hall (*A.J.* XIV, 66), the adoption of such a system, "even if not the best possible, would, as pointed out by Bessel long ago, introduce order and harmony into our observations, and render them more easy of reduction." The want of it has undoubtedly injured the symmetry of much of our astronomical work up to the present time, and increased the labor attendant upon its proper utilization.

It is generally known that Prof. Newcomb desired and intended to prepare and introduce into the *American Ephemeris*, with the year 1900, a new list of fundamental stars, and that, in view of his anticipated retirement from the Superintendency in 1897 — enforced by the operation of a peculiar and absurd law relative to the United States Navy, under which he held his office — work had been pressed forward to that end, as well as upon new determinations of the fundamental constants, which were to be similarly introduced.

At about the same time it happened as a coincidence that an agitation was begun looking to an agreement among the various national astronomical almanacs for the adoption of a common system of fundamental stars. This resulted in the organization, under the initiative of the *Bureau des Longitudes*, of a conference of the directors of the various astronomical ephemerides, to be held at Paris in 1896. The proposed constitution of this conference was that each country interested should be represented by two delegates. The actual constitution of the body, in its meetings for deliberation held on May 18, 19, 20 and 21, 1896, consisted of four representatives from France, two from England, and one each from Germany,* Russia, the Netherlands and the United States. This body was called the "*Conférence Internationale des Étoiles Fondamentales.*"

At its first meeting a program, prepared by Prof. Newcomb, was placed before it, and adopted after some amendment, as the basis of its deliberations. This program, besides the ostensible object of the gathering, embraced a subject only collaterally connected therewith; namely, the selection of a new set of values of the solar parallax, the precession, the aberration and the nutation constants, as well as some subsidiary topics. Decisions upon these questions were reached which were briefly announced during the summer of 1896. But the *Procès-Verbaux*, from which alone astronomers could form an intelligent opinion with regard to these decisions, were not distributed until nearly a year later — and then very sparingly, considering the vital interest which the astronomical world, generally, had in the matter, and its right by courtesy to full information with regard to legislation in which it had no voice. At least on this side of the Atlantic it has been exceedingly difficult to obtain a sight of these debates. This fact is sufficient warrant for the space here given to the description of the formation and proceedings of this legislative congress. It also furnishes the explanation why the open discussion, from the outside, of the wisdom of this legislation has been necessarily delayed; for manifestly no intelligent debate upon the subject could be opened until the reasons advanced in favor of the decisions could be attentively examined. In particular the point upon which astronomers were especially curious to be informed was the nature of the pressure, which the French Conference seemed to feel, calling for immediate action with regard to the constants at a time which seemed to be inopportune. In this regard it is unfortunate that the policy of precipitating the adoption of new constants in the almanacs so early as 1901 had an unwholesome tendency to forestall and prevent open discussion by astronomers generally, who have as great an interest in the matter as the compilers of these publications, and who will insist upon a voice in its ultimate decision. The unfortunate tendency spoken of will of course meet an efficient counteractive in the self-respecting resistance to what, in effect — although undoubtedly not in intention — was usurpation of authority. For it is not to be supposed that astronomers will consent, or conform their practice, to a change — especially to an ill-advised and hasty one — until, on deliberate consideration, it appears for the interest of astronomical science to make it. It is indeed singular that the Congress did not appear to perceive the true nature of the relation of the almanacs to astronomy, as a serving and not a governing agent; nor apparently appreciate either the limitations of its own powers or the suicidal tendency of its mode of reaching the desired object; — nor foresee that the result would necessarily be a diversity instead of a unity of practice of astronomers as to the constants in use in the immediate future, and would postpone the time for a final agreement, instead of accelerating it — while it would incidentally diminish the usefulness and influence of the almanacs themselves. It may be added that the failure of the Congress to secure concert of action even among its own self-limited membership — as evinced by the independent initiative taken by one of them in a premature adoption of the proposed values a year in advance of the others — is a matter of concern only to the Congress itself.

The foregoing remarks will acquaint many astronomers, who have no access to the *Procès-Verbaux* of the French Conference, with the influences and process of events that have brought matters which so importantly affect their interests to the present pass; and will make self-evident that the occasion for a polemic discussion — so much to be deplored and avoided where possible — is not properly to be laid at the door of the objectors to the adopted policy; and still more self-evident that no apology is needed for treating the decisions of the Conference as a proper subject of open and pertinent inquiry. In this connection it may also be remarked that astronomers will be at no difficulty in deciding whether any profound knowledge of lexicography is needed to judge of the propriety of Prof. Boss's use of language in his argument in the two paragraphs at the bottom of p. 113 and at the top of p. 114 (*A.J.* 423), and whether the remarks of Prof. Newcomb thereupon, near the bottom of p. 137 (*A.J.* 426), are quite just. It seems to be reasonable to expect, in view of the constraint which the almanacs unavoidably put upon the computing practice of astronomers, that the administrators of these public institutions should be delicately solicitous as to the wishes of the users of the almanacs with regard to the basis of their construction.

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* Dr. Auwers being unable to attend.

As one of the users I now take the liberty to say something about the decision of the French Conference upon the aberration-constant. I can neither pretend nor hope, in doing this, to accomplish so felicitous a combination of sound science and forcible rhetoric — from the use of which Prof. Newcomb seems so averse — as is embraced in Prof. Boss's admirable and unanswerable statement in regard to the precession-constant.

As to the aberration-constant it is apparent beyond the need of contention that no time within the past half-century could have been so inopportune for a change as the present. The number of investigations unfinished, unreduced, and in inception — the results of which will be shortly forthcoming, and which, imperatively, should be awaited — has never been so great as now. At no previous time could we so appropriately say that the true value of this element is an unknown quantity, or with so much reason exercise a reserve of opinion as to its real amount. Those who are most intimately acquainted with the present condition of the subject are most at a loss. Each successive research has its principal result in upsetting previous ideas and teaching caution as to preconceived notions. For one, having bestowed much work upon it for some years, I am willing to confess that I have less definite ideas about it than before I began; so that now I am prepared to hazard only the opinion that the limits 20″.48 and 20″.58 will probably comprise the true value when ultimately found; and that any quantity outside this rather liberal range has few chances in its favor. At any rate, however, I apprehend that a much more cogent plea could be set up, from the present standpoint of our knowledge, for a value of 20″.53, for example, than for that of the Conference.

It seems to me a most significant circumstance that the results of most recent inquiry continually tend to reinforce the result, which at one time appeared abnormal, of Nyrén's prime-vertical observations of 1875–82; which have been characterized, *A.J.* XIII, p. 65, as "altogether the finest contribution to the knowledge of the aberration-constant in the annals of astronomy" — a position of pre-eminence which they still easily hold, in my opinion. The results of the investigation of this series, in two parts, I have there given as 20″.516 and 20″.534. Mr. Newcomb has himself testified (p. 36 of the *procès*) in reply to the criticisms of Mr. Loewy, that he has also discussed these observations in every possible manner, and has always arrived at the same result, 20″.52 or 20″.53.

Quite as significant also is the circumstance that the value, 20″.57, which comes from the solar parallax found by Newcomb from the mass of the earth, through the secular variations of the orbits of the four inner planets, seems to make it easy to reconcile the conclusions of gravitational theory with what a few years ago would have been regarded as the rather improbable and apparently excessive values, according to the ideas then generally held, of the aberration towards which direct observations have recently tended. For it must be noted in passing that, by the irony of fate, the three determinations of the aberration published since the choice of 20″.47 by the French Conference, are 20″.55 (Doolittle), 20″.533 (Fergola), and 20″.57 (Finlay); while a fourth research, still more recent and not yet published, of the highest order of excellence and authority, which I do not yet feel at liberty to name, is likely to yield a still larger value. These, with other recent determinations of which I will quote only 20″.457 (Columbia), 20″.475 (Strassburg), and 20″.511 (Berlin), illustrate the highly diversified character of our information.* The cause of this variegation will be diligently sought, and we may feel confident with satisfactory results, in a very near future, when the definitive results of these and many other similar investigations now on foot can be collated. Meantime, that a settled decision upon the question is untimely, seems beyond debate.

It is now necessary to say something about the proceedings of the French Conference in this matter. In offering his proposition for the adoption of the value 20″.47, which was accepted by that body, Mr. Loewy premised (p. 34 of the *procès*) that three years ago (*i.e.* in 1893) he had, in conjunction with Mr. Puiseux, made a research, not yet published, which consisted in the assemblage of all determinations of the aberration then known, and their combination by newly assigned weights. The rule was imposed, it is said, "of conducting the discussion with entire impartiality." It appears from his description that this impartiality consisted in "abstaining from the application to the published numbers of any empirical corrections whatever, of more or less doubtful origin, and of rejecting even hypotheses sufficiently plausible which might have justified certain corrections." What is meant by these "empirical corrections" and "plausible hypotheses" is not distinctly stated, but I think we can conclude by inference — first, from his known very liberal degree of incredulity, from the beginning, with regard to the phenomenon of the variation of latitude; secondly, from his criticism of Prof. Newcomb for having introduced the variation of latitude as an element in the determination of the aberration; thirdly, from his specific characterization, in the same debate, of this variation as a "*rectification empirique*" — that this omission to consider the variation of latitude was an important feature of the impartiality which he imposed upon his treatment of the aberration, as described. If I am not correct in this inference I shall be glad to make due apology.

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* In addition to what has been said in the article above, I should add that since it was in type there has come to hand from Professor Doolittle a determination, from his observations of 1896–7, with the beautiful instrument with which he is now prosecuting his work at the Flower Observatory of the University of Pennsylvania. This value is 20″.572. It is hoped to present this contribution of Doolittle's in the next number of the *Journal*.

Now, there are a very considerable number of astronomers in the world who believe that the phenomenon of the variation of latitude has taken its place in the body of approved astronomical knowledge, by the force of the combined labors of its many investigators, as firmly as the precession and nutation of the equinoxes or as the aberration of light. A very considerable proportion, too, think that a sufficient knowledge of the laws of these variations has been reached to enable us to take account of them in the determination of the various fundamental constants, and that it is especially futile to attempt to find the amount of the aberration by ignoring them; so that, if we do ignore them, our results must be rejected.

Now Mr. Loewy is of course free to hold any opinion upon this subject that commends itself to his mind, but when he asks consideration and adoption of a value of the aberration-constant determined by a process which, in effect, turns back the hands upon the dial of astronomical progress, his proposition becomes a proper subject for criticism. It is much to be regretted that his treatment of the aberration exists only in manuscript and is not accessible for examination. But such information as he has presented permits us to make one or two pertinent comments. From his remarks about the character and weight which he attributes to W. Struve's result, it is manifest that it has contributed not unimportantly to define his mean value. But his refusal to recognize the latitude-variation must have gravely prejudiced this mean value; for it has been shown that Struve's determination, beyond all others of a high class, is unfortunately so involved with the latitude-variation that the aberration is very nearly indeterminate from it. All that can be said is that it indicates a constant somewhere between 20″.47 and 20″.50. Mr. Loewy has used, without change, the original value, which is now proved to be fallacious. I submit that it is incumbent upon him to destroy the validity of the argument in *A.J.* XIII, pp. 57 foll., before we can accept his method of dealing with this determination, as well as with others. He must also be asked to do the same with the argument in vol. XII, p. 178, where it is demonstrated that all determinations of the aberration from zenith-distances of a single star, on one side of the pole only, are fallacious. Until he does this we must exclude his determination if it contains results found in this manner, as is probable. Again he mentions the fact that he has taken Küstner's result of 1884–5 as originally given, 20″.31, while Newcomb has used 20″.46 as corrected for variation of latitude. I may incidentally suggest that there is probably some oversight of Prof. Newcomb here, as I get from this series 20″.61. It is possible that Newcomb has overlooked the fact that Küstner's absolute terms, in the equations on pp. 38–44 of his memoir, require correction by twice the latitude-variation. At least this would account for our different results. But whether this is so or not, Loewy's result is vitiated. But it is unnecessary to go any farther into details. Let us come back then to the essential position, which is this: The time is unripe for any decision as to the constant of aberration. The immediate future is rich with promise of fruitful contributions, which must be awaited. We do not want to run the risk, almost certainly imminent if the action of the Conference is adhered to, of having to make two changes within a brief period, in this important element of computation. The temporary retention of the confessedly imperfect value at present in use will simplify the process of correcting existing observations, when we can intelligently make a change. The insignificant, premature and necessarily provisional alteration of only 0″.025 will only serve to increase the vexation in making such corrections. Our position, to sum up, is therefore identical with regard to the precession and aberration. There can be no dissenting voice against the wisdom of Prof. Newcomb's aphorism (p. 24 of the *procès*) that "it is always inconvenient to change the fundamental numbers of Astronomy, but it sometimes happens that a large change brings less confusion than a slight modification." It is a pity that the Conference should not have paused to reflect on the pregnancy of this saying before committing itself to corrections numerically smaller than their probable errors.

Finally, let not Prof. Newcomb give way to despair because "the time will never arrive when astronomers will all agree, as to what are the most probable values of the astronomical constants." It indeed never will. We are not waiting for it, as he appears to think. Whoever expects it may dismiss the fond fancy without regret, as having nothing to do with the prospect for an agreement upon conventional values, which will quickly come when the large amount of material now in sight is actually in our grasp. However diverse its nature, harmony of view as to its interpretation and use will then be easily realized: first, because the art of discussing the results of scientific observations will not meanwhile have been lost; secondly, because the occasion for further waiting will then have disappeared, and no factious objection to closing the account and striking a balance can reasonably stand in the face of the common sense of astronomers. Can any one have so poor an idea of the intelligence, open-mindedness and disposition to work for the common good, of his brethren in science, that he cannot join in this hopeful view?

These expressions of dissent from the conclusions of the Conference are strong. But I must ask as a right that they be not regarded as implying any want of respect for the eminent scientists who composed it, whose brilliant attainments we all cherish in common as the proud heritage of our science.

ON THE INTENSITY OF THE IMAGE OF AN INFINITE LUMINOUS AREA; A REPLY.

By J. M. SCHAEBERLE.

I desire to reply very briefly to Prof. WADSWORTH's remarks in *A.J.* 424 (received to-day), so far as they concern my note in *A.J.* 421; and, in order to save space, I shall refer to statements already printed in the *Astronomical Journal*, instead of making quotations.

My interpretation of Lord RAYLEIGH's language as quoted on page 124 (*A.J.* 124) differs from Prof. WADSWORTH in this particular: the point "*O*" and "any other point" are — I take it — not only in the same focal plane, but the focal distance of this plane is supposed to be constant for the given case.

I confess, therefore, that I really did think, and still do believe that Prof. WADSWORTH (although misled by an ambiguous statement of RAYLEIGH's), is alone responsible for the statement whose truth I called in question. I realize, however, that in holding this view I may unknowingly be doing him an injustice.

The revised formulas which Prof. WADSWORTH deduces in *A.J.* 424 I am unable to accept as correct. He now finds that his previous expression for the *intensity* must be multiplied by $\frac{D^2}{f^2}$, in which D represents the distance of the luminous source from the objective, and f denotes the focal length.

Now, it is well known that the *intensity* of a large (infinite) luminous surface (*not the image of this surface* when the focal length varies) per unit of angular area is the same at all distances. Yet, according to Prof. WADSWORTH's revised formulas — if I interpret them correctly — the *intensity* of the focal image for a given value of f is not only dependent on the distance of the luminous area, but actually *increases* as the square of the distance *increases!*

Leaving aside all consideration* of Prof. WADSWORTH's formulas, his whole trouble in the special case of the image of an infinite luminous area seems to me to be due, as I have already indicated in my previous note on this subject, to a misinterpretation of the meaning of the integral given on page 102, *A.J.* 421. He calls it the expression for the *intensity*; while I hold that it represents the *total illumination* of the focal plane, and that therefore the intensity (per focal unit-area) at any given angular distance from the optical axis, must vary inversely as the square of the distance (of this focal unit-area) from the objective, just as the formulas leading up to this integral also show.

Lick Observatory, University of California, 1898 *Jan.* 21.

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* Referring simply to RAYLEIGH's memoir.

SOLAR ECLIPSE EXPEDITION OF THE LICK OBSERVATORY.

A cable dispatch received at Mt. Hamilton from Professor CAMPBELL, who is in charge of the Crocker Lick Observatory Expedition at Jeur, India, states that most satisfactory photographs of the corona were obtained with three different telescopes. One set with a telescope 40 feet long, and two other sets with five-foot and three-foot telescopes. He also reports that the great equatorial extension of the corona, which formed such a conspicuous feature of the eclipse of January, 1889, has again been photographed.

He also satisfactorily photographed the changes in the solar spectrum at the sun's edge with the aid of one of the spectroscopes, and probably obtained successful photographs of the reversing layer with the aid of a second spectroscope.

Lick Observatory, University of California, 1898 *Jan.* 24.

J. M. SCHAEBERLE.

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OBSERVATIONS ON PROFESSOR NEWCOMB'S DETERMINATION OF THE PRINCIPAL ELEMENT OF PRECESSION,

By G. W. Hill.

Prof. Newcomb has recently published a memoir (*Astronomical Papers*, Vol. VIII, Part I) on precession which has excited some discussion in view of the possible adoption of the value arrived at by the principal astronomical ephemerides. As the matter is of great interest, I take the liberty of communicating the observations which the reading of the memoir has suggested.

Prof. Newcomb, on p. 10 of his memoir, divides the work of referring the right-ascensions of the stars to the vernal equinox into three divisions, of which he declines to consider the first two because the French Conference of 1896 resolved that, for the future, the departure-point from which right-ascensions are to be counted shall not be subject to correction, but shall be identical with that which obtains with the 32 stars of system N_1. This resolution means that astronomers shall give up their custom of counting right-ascensions from the vernal equinox and adopt a point of departure quite arbitrarily defined. Now, without remarking on the undesirableness of allowing half a dozen men to choose the methods of astronomers, let us point out the inconveniences of this change. If it is adopted, those who attempt to rectify the right-ascensions of system N_1 will be obliged, at every epoch, to make the sum of their corrections vanish. Moreover, the right-ascension of the latitude-less sun, at the time when the declination vanishes, will be found to deviate more and more from 0^h and 12^h. In consequence, if astronomers still use longitudes and latitudes, as it is to be supposed they will, the present simple formulas for transforming one kind of co-ordinates into the other, which contain only one element, viz., the obliquity of the ecliptic, will have to be complicated by the addition of one or two more. This proposal somewhat resembles that which was made many years ago that the mean right-ascension of *α Andromedae* should be made zero, and which was never adopted.

After Prof. Newcomb had made the statement at the foot of p. 10, the reader of the memoir naturally expects to find a discussion conducted in accordance with the resolution of the French Conference; and so he does, until the second paragraph of p. 69 is reached, when, emancipating himself from the binding force of this resolution, Prof. Newcomb proceeds to consider how much difference there is between the departure-point of system N_1 and the actual equinox. Now this is not only a surprise to the reader, but has involved Prof. Newcomb himself in forgetfulness. It has been the usual custom of astronomers to conduct the work of referring their right-ascensions to the equinox as one operation, instead of dividing it into three portions as Prof. Newcomb does. It is, perhaps, some reminiscence of this habit which has led Prof. Newcomb to forget that, when he came to consider on p. 69 the value of the quantity he denotes by ΔE, he ought to admit the evidence of the observers who have referred their right-ascensions to the sun as to the point whether system N_1 is properly referred to the sun. Now, since in Auwers's reduction of the Bradley observations the right-ascensions are referred to the sun, the difference $\Delta\alpha\ 1755 = -0^s.079$* is evidence that, so far as the comparison of 32 stars can show it, the departure-point of system N_1 is, at the epoch 1755, $0^s.079$ ahead of the equinox. We might explain Prof. Newcomb's neglect of this evidence on the supposition that he deems Bradley's observations of the sun worthless for the purpose of defining the position of the equinox. But then they would also be worthless for determining the elements of the earth's orbit, and we find, on turning to the *Fundamental Constants of Astronomy*, p. 3, that Prof. Newcomb has used them for this purpose. In like manner, the difference $+0^s.024$ given by two Greenwich Catalogues for the epoch 1860 is evidence that the equinox of N_1 is behind the actual equinox by that amount. This evidence, however, may be supposed to be considered in the determination of $\Delta E'$ on p. 71.

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* I must here record my impression that this number is in error. By subtracting the R.A.'s of the 32 stars contained in the third volume of Auwers's *Neue Reduction* from the values for 1755 given at the end of *Equatorial Fundamental Stars*, and taking the mean, the result is $-0^s.066$; and this accords with the result got by subtracting $+0^s.056$, Auwers's correction to Bessel's equinox for Bradley, from the $-0^s.010$ given at p. 43 of the memoir just mentioned. I at first supposed that the difference might be occasioned by diverse modes of measuring R.A. in the cases of *Sirius* and *Procyon*, which stars have been included in the comparison; but it does not seem that the discordance can be thus explained.

It would seem that the discordance between the two results $\delta p = +0''.245$ and $\delta p = +1''.340$, on p. 35, ought to have led Prof. NEWCOMB to the suspicion that the departure point of system N_1 does not move with a velocity identical with that of the actual equinox: yet we find him at p. 71 speaking of "the great mass of material on which the equinox for the system N_1 is based" as a ground for incredulity as to any correction being needed.

Had Prof. NEWCOMB, instead of using the system N_1 as the provisional standard for comparison, used another in which the annual variations are uniformly $0^s.00067$ less, he would have found the two mentioned results in exact accordance with each other; and the use of such a system would be quite as legitimate as that of N_1.

Now the centennial correction $+0^s.098$ we see at the foot of p. 12, given as the correction to make the motion of the stars derived from Greenwich observation agree with that of system N_1, would lead us to anticipate just such a result as we find in the two values $\delta p = +0''.245$ and $\delta p = +1''.340$. The employment of 2500 stars in place of 32 has served to cut the correction down from $-0^s.098$ to $-0^s.067$. The value $\Delta E' = +1''.0$ on p. 71, which is derived from the observed right-ascensions of *Mercury*, comes to confirm this conclusion. The divergence of the first given result, viz., $\Delta E' = +0''.5$, is due either to the shortness of the period, 60 years, embraced by the observations on which it is founded, or to the "rough investigation" which, as Prof. NEWCOMB admits, was employed to obtain it. If Prof. NEWCOMB will use the whole period of observation at Greenwich, viz., 1755–1895, he will find a result substantially in accord with his value from the right-ascensions of *Mercury*.

The insufficiency of the reference of system N_1 to the sun is a point so important to be established that I do not hesitate to give here some details in relation to it.

In the *Equatorial Fundamental Stars*, p. 33, Prof. NEWCOMB gives a table of the material he employed for referring the system N_1 to the equinox; but, in giving the resulting values of the two unknowns, he does not state their probable errors. Now, from the data of this table, it may be found that the probable error of the known term of an equation with the weight unity is $\pm 0^s.053$; and thence the probable error of the unknown y', denoting the correction of the centennial variations, is $\pm 0^s.025$. Consequently, the value of δp which is derived from right-ascensions at p. 35 of the memoir on precession, ought to be affected with the probable error $\pm 0''.41$. But, in fact, these probable errors do not give the real measure of uncertainty of the quantities to which they are attached, because the errors are constant rather than periodic. I should be inclined to advance the $\pm 0^s.025$ to $\pm 0^s.040$; then δp would have the probable error $\pm 0''.65$.

Prof. NEWCOMB has included in his material two equinoxes, determined severally by PIAZZI and MASKELYNE, about which we have no details, no knowledge of how many observations of the sun were employed, or whether the authors took the precaution of using an equal number of autumnal and vernal equinoxes. In fact, there is much ground for suspicion that they used very slovenly methods in their elaboration of the matter. If AUWERS found a correction of $0^s.056$ to BESSEL's equinox for BRADLEY, what may we expect will be the corrections to PIAZZI and MASKELYNE when their observations are rehandled in the more careful modern way? However, the large differences between these observers and the rest of astronomers is quite likely to be the result of systematic errors made in the declinations of the sun which are not the same at the two equinoxes. It seems we have good reasons for insisting that these two equinoxes should be rejected.

There is also another determination of equinox, viz., that of Paris for 1865, which Prof. NEWCOMB has included in his list, and which seems affected with systematic error. The remarks on the Paris observations, made by Prof. NEWCOMB at p. 27 of *Fundamental Stars*, are pertinent here. We may fear that personal equation unfavorably affects the observations of 1864 and 1865 as well as those which follow. However, in the treatment of the material which follows, not liking to reject the Paris result, I have made two solutions, in one of which it is retained, and in the other, rejected.

I have then modified Prof. NEWCOMB's material by making the correction given by BRADLEY conform to AUWERS's determination of the equinox, by rejecting PIAZZI and MASKELYNE, by substituting a comparison with the Greenwich Nine-Year Catalogue for the result of 1869, by adding a comparison with Ten-Year Catalogue, as also one from observations at the Radcliffe Observatory in the years 1884–1891 (*Catalogue of* 6424 *Stars for the epoch* 1890, *formed from observations made at the Radcliffe Observatory, Oxford, during the years* 1880–1893. *By* E. J. STONE), and by adding a result from Greenwich observations in the years 1887–1894. As to the last result, the corrections for equinox given in the annual volumes stand thus:

1887	$-0^s.059$	1891	$+0^s.088$
1888	$+0.072$	1892	$+0.040$
1889	$+0.024$	1893	$+0.090$
1890	$+0.093$	1894	$+0.042$

From this exhibit we might imagine that new positions for clock-stars were introduced into the observatory at the beginning of 1888; but no sensible change was made, and the large difference of the two years 1887 and 1888 must be ascribed to the advent of new observers with personal equations differing much from those of the previous observers. I have added a third decimal to the data of Prof. Newcomb, when I could readily discover what it should be; this because a change of $0^s.01$ in the datum for 1756 produces one of $0''.006$ in the value of Prof. Newcomb's y'.

The collection of data is then shown by the following table:

Authority	Date	Eq. Corr.	Years	Weight	Residuals O – C I	 II
		s			s	s
Bradley (Auwers)	1756	+0.120	7	3	+0.041	+0.034
Bessel I	1817	+0.053	3	2	+0.013	+0.015
Bessel II	1822	–0.002	5	4	–0.039	–0.036
Pond	1823	+0.072	14	4	+0.036	+0.038
Struve	1825	+0.040	5	4	+0.005	+0.008
Argelander	1828	+0.064	4	3	+0.031	+0.034
Cambridge	1835	–0.029	5	2	–0.057	–0.053
Edinburgh	1838	+0.040	4	2	+0.014	+0.018
Greenwich	1839	–0.052	6	3	–0.078	–0.073
Berlin	1841	–0.060	4	2	–0.085	–0.080
Cambridge	1841	+0.060	5	2	+0.035	+0.040
Edinburgh	1842	–0.008	4	2	–0.032	–0.027
Pulkova	1845	–0.005	8	5	–0.027	–0.022
Greenwich	1845	–0.003	6	3	–0.025	–0.020
Cambridge	1849	+0.060	5	2	+0.041	+0.047
Greenwich	1851	+0.017	6	3	–0.001	+0.005
Cambridge	1856	–0.010	5	2	–0.025	–0.018
Greenwich	1857	–0.005	7	3	–0.019	–0.012
Paris	1859	+0.002	10	4	–0.011	–0.004
Greenwich	1864	–0.021	7	3	–0.031	–0.023
Washington	1864	+0.052	4	4	+0.042	+0.050
Paris	1865	+0.115	2	2	+0.106	+0.114
Washington	1867	+0.053	4	4	+0.045	+0.054
Greenwich	1872	–0.021	9	4	–0.026	–0.016
Greenwich	1882	–0.023	10	4	–0.021	–0.011
Oxford (Radcliffe)	1888	–0.013	8	3	–0.007	+0.004
Greenwich	1890	+0.018	8	3	+0.025	+0.037

Adopting Prof. Newcomb's unknowns, viz., x' for the correction at 1820, and y' for its change in a century, we have the following normal equations when the Paris result for 1865 is retained:

$$\begin{aligned} 82x' \quad +22.63y' &= +1^s.484 \\ 22.63x' +12.11y' &= -0^s.019 \end{aligned}$$

The probable error of the known term of an equation of the weight 1 is $\pm 0^s.043$, and the values of the unknowns with their probable errors, are

$$x' = +0^s.038 \ \pm 0^s.007 \quad , \quad y' = -0^s.073 \ \pm 0^s.018$$

If we omit the Paris result, the probable error attached to weight 1 is reduced to $\pm 0^s.038$, and the values of x' and y' with their probable errors become

$$x' = +0^s.036 \ \pm 0^s.006 \quad , \quad y' = -0^s.078 \ \pm 0^s.016$$

The residuals of these two solutions are noted in the columns of the table headed I and II.

As the values deduced by Prof. Newcomb are $x' = +0^s.016$ and $y' = -0^s.009$, the two solutions severally give the following corrections to the system N_1:

$$\begin{aligned} \varDelta N_1 &= +0^s.022 \ -0^s.064\ T \\ \varDelta N_1 &= +0^s.020 \ -0^s.069\ T \end{aligned}$$

These corrections are in substantial accord with the value $\varDelta E' = +1''.0$ found from the right-ascensions of *Mercury*.

If we adopt $\varDelta E' = +0''.98$ and substitute this value in Prof. Newcomb's equation

$$\delta p = +0''.36 \ +1.09\ \varDelta E'$$

we get the correction to precession as derived from right-ascensions $\delta p = +1''.43$. As to the result from declinations, it seems to me that we ought to adhere to the value given on p. 35, viz., $\delta p = +1''.31$. The weights to be attached to these results seem about equal. The value $\delta p = +1''.39$ may then be taken as the combination of the two. This leads to $50''.2510$ as the annual general precession for 1850; a value which is only a trifle less than that of PETERS.

If I may be pardoned for intervening in the discussion which has arisen between Prof. NEWCOMB and BOSS in regard to the material which may be judiciously employed in the determination of precession, I will add here a few words.

With regard to the variation of personal equation with stellar magnitude, all we know of physiological optics would incline us to suppose that the great part of this variation lies between the first and sixth magnitudes and not between the latter and the last that is visible. If this supposition is incorrect, experimentation with personal equation machines ought to give us some light on this point, unless, as perhaps Prof. NEWCOMB will maintain, the nervous system of persons who exclusively use the eye-and-ear method is in a quite different condition from that of those who generally use the chronographic method. But, however this may be, the results in right-ascension given by Prof. NEWCOMB at p. 35 exhibit not the slightest trace of ill effects owing to this variation. From magnitudes 3 to 6 they are almost identical, and the differences noted in the results belonging to magnitudes 1–2 and 7 are plainly due to the paucity of the stars included. I think we may conclude that we may safely go on adding groups of the 8th and smaller magnitudes.

Even if we admit Prof. NEWCOMB's plea that the BRADLEY-stars are the only ones it is worth while to consider, because they alone have been observed as early as 1750, and also admit that BRADLEY alone must fix the farther end of the chain, we must still insist that the nearer end must be made as strong as possible and that the chain should have the greatest length possible. In regard to the latter condition, what has Prof. NEWCOMB done? He has used no later observations of the BRADLEY-stars at Greenwich than those made in 1875, while he might have included those made in the 18 years 1876–1893. Surely, to have extended the interval of time from 125 to 143 years would have been worth the extra labor.

But a very reasonable objection to the result of Prof. NEWCOMB's work in this matter is that it is founded almost entirely upon the material afforded by a single observatory — Greenwich. There are now at least 15 observatories where some of the observing is devoted to obtaining positions of the BRADLEY-stars. The published part of this might have been used to strengthen the nearer end of the chain. What voice, we may inquire, has Pulkowa had in determining the element under consideration? None but that involved in fixing the right-ascensions of system N_1, and also, perhaps, in the formation of the mean system of declinations. But this is not as much as should be conceded.

SECULAR PERTURBATIONS OF *VENUS* FROM THE ACTION OF THE *EARTH*.

BY ERIC DOOLITTLE.

The following computation has been made according to Dr. G. W. HILL's first method. It will be observed that the sums of the functions corresponding respectively to the odd and even points of division of the orbit are not in sufficient agreement to furnish a test of the work. The differences clearly begin with the roots G, G' and G'', and gradually accumulate. These roots were therefore obtained in two different ways: first, by the formulas of Dr. HILL's memoir, page 328, and second, by the formulas given in the *Astronomical Journal*, No. 386. The first results were tested by the formulas of Dr. HILL, page 328, and the second by the equations on pp. 327 and 355. The equation, $hl = B^2 - AC$, was also applied to test the first solution. These results were in agreement.

Beside duplicating the computation from the beginning, the values of A, B, ϵ, J_1', J_2, J_3, F_2 and F_3 were tested by equations similar to those published by Mr. R. T. A. INNES (*Monthly Notices*, Vol. LIII, No. 6). The computation of θ and r was carried through a third time, as no tests of these critical functions were known. The formulas employed were:

$$\tan^2\theta = \frac{G'+G''}{G-G'} \quad r = ar'^2(G+G'')^{-3/2}.\left[\mathfrak{E}''(G+G'') - \mathfrak{E}'G''\right].\mathfrak{K}$$

It was not considered necessary to increase the number of points of division to twenty-four, since in previous cases, in which the disagreement was much greater, the additional functions have not altered the results. Thus, the final values of Σ_1 and Σ_2 in the action of *Mercury* on *Venus* disagree in the *second* decimal when twelve points of division are employed, but upon increasing the number to twenty-four, it is found that $\frac{1}{2}(\Sigma_1 + \Sigma_2)$ was correct to at least the eighth decimal.

The elements employed are from Dr. HILL's "*New Theory of Jupiter and Saturn*," pp. 192 and 554.

Venus.		*Earth.*	
π =	129° 27′ 42″.83	π' =	100° 21′ 39″.73
i =	3 23 35.01	i' =	0 0 0.00
☊ =	75 19 53.08	☊′	
e =	0.006 84311	e' =	0.016 77114
$\log a$ =	9.859 3378	$\log a'$ =	0.000 0000
n =	2106641″.357	n' =	1295977″.416
m =	1 ÷ 408,134	m' =	1 ÷ 327,000

Epoch 1850.0 G.M.T.

The following values were obtained for the preliminary constants and the auxiliary functions:

I =	3° 23′ 35″.01	$\log k$ =	p9.999 8637
Π =	234 7 19.75	$\log k'$ =	p9.999 3746
Π' =	205 1 46.65	$\log c$ =	p6.449 1252
K =	29 8 21.75	c =	0.000 281 27416
K' =	29 3 44.28		

E	v	$\log r$	A	$\log B$	ϵ	g	h
°	° ′ ″				° ′ ″		
0	0 00 0.00	9.856 3557	1.537 11333	9.864 6525	28 24 44.89	0.000 034 14346	1.002 34463
30	30 11 47.87	9.856 7564	1.529 32317	9.861 1951	58 8 48.38	0.000 107 08849	1.003 72554
60	60 20 24.50	9.857 8493	1.519 85488	9.857 3670	88 8 39.42	0.000 145 68124	1.003 14070
90	90 23 31.50	9.859 3378	1.511 25435	9.854 1284	118 22 26.90	0.000 111 22751	1.001 20600
120	120 20 20.31	9.860 8213	1.505 83081	9.852 0995	148 45 59.20	0.000 038 27088	0.999 83131
150	150 11 43.65	9.861 9040	1.505 03256	9.851 6451	179 14 28.38	0.000 000 02491	1.000 35530
180	180 00 0.00	9.862 2996	1.509 06482	9.852 9706	209 42 15.44	0.000 035 09098	1.002 26402
210	209 48 16.35	9.861 9040	1.516 84286	9.855 9800	240 2 15.31	0.000 108 76150	1.003 70935
240	239 39 39.69	9.860 8213	1.526 28659	9.860 0280	270 7 30.07	0.000 147 63156	1.003 26746
270	269 36 28.50	9.859 3378	1.534 87476	9.863 9340	299 51 45.01	0.000 112 93247	1.001 33526
300	299 39 35.50	9 857 8493	1.540 31063	9 866 4105	329 27 9.54	0.000 039 27365	0.999 85008
330	329 48 12.13	9.856 7564	1.541 13325	9.866 6454	358 53 34.66	0.000 000 05681	1.000 36791
Σ_1	900 00 0.00	9.155 9965	9.138 46106	9.153 5281	1074 36 18.56	0.000 440 09177	6.010 69819
Σ_2	1080 00 0.00	9.155 9964	9.138 46095	9.153 5280	1254 36 18.64	0.000 440 09169	6.010 69936

E	l	G	G'	G''	θ	$\log \mathfrak{K}$	$\log \mathfrak{L}'$	$\log \mathfrak{N}$
°					° ′ ″			
0	0.534 48743	1.002 27181	0.534 62398	0.000 063 71969	46 55 3.02	0.260 00336	0.605 98257	0.545 77154
30	0.525 31637	1.003 50237	0.525 74251	0.000 202 97911	46 22 33.07	0.252 88171	0.597 19127	0.536 14961
60	0.516 43292	1.002 84204	0.517 01255	0.000 280 97656	45 53 55.40	0.246 73133	0.589 58546	0.527 81896
90	0.509 76708	1.000 97979	0.510 21108	0.000 217 78955	45 33 15.30	0.242 46622	0.584 30371	0.522 03035
120	0.505 71823	0.999 75382	0.505 87139	0.000 075 67200	45 20 14.51	0.239 74361	0.580 92896	0.518 33025
150	0.504 39599	1.000 35525	0.504 39608	0.000 000 04937	45 14 29.83	0.238 44519	0.579 31865	0.516 56434
180	0.506 51953	1.002 19338	0.506 65928	0.000 069 10794	45 19 11.90	0.239 42219	0.580 53038	0.517 89317
210	0.512 85225	1.003 48844	0.513 28431	0.000 211 15665	45 39 53.44	0.243 75790	0.585 90391	0.523 78440
240	0.522 73786	1.002 96095	0.523 32564	0.000 281 26987	46 15 21.69	0.251 32635	0.595 26901	0.534 04476
270	0.533 25822	1.001 09414	0.533 71072	0.000 211 36737	46 54 18.41	0.259 83876	0.605 77958	0.545 54943
300	0.540 17928	0.999 76461	0.540 33745	0.000 072 70065	47 19 22.49	0.265 43283	0.612 67386	0 553 08969
330	0.540 48407	1.000 36779	0.540 48430	0.000 000 10507	47 18 38.53	0.265 26804	0.612 47091	0.552 86781
Σ_1	3.126 07525	6.009 78661	3.127 83029	0.000 843 44671	277 3 39.01	1.502 65967	3.564 97024	3.196 94837
Σ_2	3.126 07397	6.009 78778	3.127 82900	0.000 843 44712	277 3 38.58	1.502 65782	3.564 96803	3.196 94594

E	$\log N$	$\log P$	$\log Q$	$\log V$	$\log J'_1$	J_2	J_3	F_2
°								
0	9.830 5330	0.434 4894	0.375 2914	0.375 2596	9.998 9053	+0.004 202 020	−0.047 236 424	−0.005 832 177
30	9.823 3230	0.417 3018	0.357 8664	0.357 7653	9.998 4573	+0.010 025 286	−0.058 127 293	−0.010 328 762
60	9.819 7364	0.406 6135	0.346 2012	0.346 0609	9.998 7381	+0.013 405 599	−0.053 273 840	−0.012 046 994
90	9.819 6999	0.402 9640	0.341 2105	0.341 1015	9.999 4598	+0.012 206 904	−0.033 976 547	−0.010 526 476
120	9.820 8350	0.401 9120	0.339 2393	0.339 2013	9.999 8965	+0.006 516 023	−0.005 406 098	−0.006 171 632
150	9.821 3596	0.400 3696	0.337 7696	0.337 7695	9.999 6196	−0.001 172 845	+0.024 782 063	−0.000 157 532
180	9.821 8870	0.400 4544	0.338 7987	0.338 7641	9.998 9076	−0.007 608 410	+0.048 499 056	+0.005 912 547
210	9.824 4982	0.407 1947	0.346 6789	0.346 5734	9.998 4629	−0.010 818 504	+0.059 389 945	+0.010 409 132
240	9.830 1980	0.422 6554	0.362 8370	0.362 6968	9.998 7248	−0.010 873 469	+0.054 536 468	+0.012 127 366
270	9.837 0023	0.441 6487	0.381 9851	0.381 8798	9.999 4372	−0.008 962 465	+0.035 239 146	+0.010 606 846
300	9.840 5753	0.453 3906	0.393 7357	0.393 6994	9.999 8916	−0.005 884 342	+0.006 668 715	+0.006 255 003
330	9.837 8789	0.450 0302	0.390 5869	0.390 5868	9.999 6274	−0.001 520 954	−0.023 519 435	+0.000 237 902
Σ_1	8.963 7646	2.519 5152	2.156 1032	2.155 6821	9.995 0639	−0.000 242 579	+0.003 787 877	+0.000 241 113
Σ_2	8.963 7618	2.519 5089	2.156 0973	2.155 6763	9.995 0642	−0.000 242 578	+0.003 787 879	+0.000 241 110

E	$\log F_3$	R_0	S_0	W_0	$\frac{1}{a}\sin E\, R^{(n)}$	$\frac{1}{a} S^{(n)}$
0	+0.000 201 22394	0.421 26107	−0.005 890 097	−0.111 53496	+0.000 0000	−0.008 199 111
30	+0.000 060 17487	0.406 75651	−0.004 150 418	−0.132 32119	+0.282 8447	−0.005 772 122
60	−0.000 294 85277	0.404 41131	−0.000 984 602	−0.118 94014	+0.485 8587	−0.001 365 876
90	−0.000 508 23894	0.411 01802	+0.000 151 227	−0.075 80674	+0.568 2286	+0.000 209 069
120	−0.000 365 63277	0.416 46740	−0.001 349 097	−0.012 72800	+0.496 9244	−0.001 858 754
150	−0.000 008 56116	0.414 03810	−0.002 948 800	+0.053 91799	+0.284 5157	−0.004 052 670
180	+0.000 206 80805	0.407 10579	−0.001 730 893	+0.106 32289	−0.000 0000	−0.002 376 680
210	+0.000 065 59223	0.405 36093	+0.002 554 045	+0.132 08012	−0.278 5530	+0.003 510 140
240	−0.000 291 05383	0.415 26071	+0.007 029 019	+0.124 94379	−0.495 4847	+0.009 684 416
270	−0.000 507 07628	0.432 89840	+0.007 732 079	+0.083 49760	−0.598 4781	+0.010 689 527
300	−0.000 367 41788	0.444 51245	+0.003 199 250	+0.015 46615	−0.534 0294	+0.004 438 118
330	−0.000 012 81582	0.438 93384	−0.003 068 000	−0.057 84756	−0.305 2198	−0.004 266 768
Σ_1	−0.000 910 92526	2.509 01873	+0.000 273 580	+0.003 52943	−0.046 7370	+0.000 322 113
Σ_2	−0.000 910 92510	2.509 00580	+0.000 270 133	+0.003 52022	−0.046 6619	+0.000 317 176

E	$R_0 \sin v$ $+ (\cos v + \cos E)\, S_0$	$-R_0 \cos v$ $+\left(\frac{r}{a}\sec^2\varphi + 1\right)\sin v\, S_0$	$W_0 \cos u$	$W_0 \sin u$	$-2\frac{r}{a} R_0$
0°	−0.011 78019	−0.421 26107	−0.065 352 939	−0.090 38273	−0.836 75673
30	+0.197 40436	−0.355 72418	−0.013 079 792	−0.131 67315	−0.808 69188
60	+0.350 44516	−0.201 83130	+0.049 268 295	−0.108 25646	−0.806 05518
90	+0.411 00745	+0.003 11509	+0.061 732 775	−0.043 99687	−0.822 03604
120	+0.360 78900	+0.208 03111	+0.012 668 751	−0.001 22668	−0.835 78481
150	+0.210 90709	+0.356 33148	−0.049 130 989	−0.022 21027	−0.832 98365
180	+0.003 46179	+0.407 10579	−0.062 298 971	−0.086 15914	−0.819 78340
210	−0.205 90981	+0.349 19573	−0.013 955 080	−0.131 34085	−0.815 52660
240	−0.365 45661	+0.197 60050	+0.050 403 535	−0.114 32600	−0.833 36328
270	−0.432 94230	−0.012 50179	+0.067 326 200	−0.049 38656	−0.865 79680
300	−0.383 08894	−0.225 51772	+0.015 375 410	−0.001 67292	−0.885 98306
330	−0.226 07885	−0.376 29530	−0.052 873 488	−0.023 46769	−0.872 66531
Σ_1	−0.045 62979	−0.035 87269	+0.000 064 081	−0.402 02393	−5.017 72616
Σ_2	−0.045 61206	−0.035 87897	+0.000 019 626	−0.402 07539	−5.017 70028

The equation $\sin q \cdot \frac{1}{2} A_1^{(s)} + \cos q\, B_0^{(c)} = 0$ is found to give the residual +0.000 000 008 1. It may be remarked that the residuals from the Σ_1's alone, and those obtained from the Σ_2's alone are nearly equal, but with contrary signs.

If m' is left indefinite, the following values of the differential coefficients result:

		log coeff.
$\left[\frac{de}{dt}\right]_{00} =$	$-\ 16017.''410\ m'$	$n4.204\,5923$
$\left[\frac{d\chi}{dt}\right]_{00} =$	$-1840673.3\ m'$	$n6.264\,9767$
$\left[\frac{di}{dt}\right]_{00} =$	$+14.695\ m'$	$p1.167\,1802$
$\left[\frac{d\Omega}{dt}\right]_{00} =$	$-2385136.3\ m'$	$n6.377\,5132$
$\left[\frac{d\pi}{dt}\right]_{00} =$	$-1844854.1\ m'$	$n6.265\,9621$
$\left[\frac{dL}{dt}\right]_{00} =$	$-1765973.3\ m'$	$n6.246\,9841$

If we adopt for m' the value given above, we have finally.

$$\left[\frac{de}{dt}\right]_{00} = -0.''048\,98290 \qquad \left[\frac{d\Omega}{dt}\right]_{00} = -7.''293\,993$$

$$\left[\frac{d\chi}{dt}\right]_{00} = -5.628\,9701 \qquad \left[\frac{d\pi}{dt}\right]_{00} = -5.641\,7558$$

$$\left[\frac{di}{dt}\right]_{00} = +0.000\,041\,940 \qquad \left[\frac{dL}{dt}\right]_{00} = -5.400\,5288$$

The results of LeVerrier are given in the "*Annales de l'Observatoire de Paris.*" Tome II, pp. 58 to 66, and Tome VI, p. 6. Those of Newcomb are found in his work on "*The Secular Variations of the Orbits of the Four Inner Planets.*" pp. 337 and 376. Reducing all to the same value of m' ($m' = 1 \div 327.000$), the three series compare as follows:

	Results of LeVerrier	Results of Newcomb	Method of Gauss
$\left[\frac{de}{dt}\right]_{00} =$	−0.''04875	−0.''04896	−0.''018983
$e\left[\frac{d\pi}{dt}\right]_{00} =$	−0.03873	−0.03852	−0.038607
$\left[\frac{di}{dt}\right]_{00} =$	−0.00006	+0.00004	+0.0000419
$\sin i\left[\frac{d\Omega}{dt}\right]_{00} =$	−0.43154	−0.43169	−0.431698
$\left[\frac{dL}{dt}\right]_{00} =$	−5.397	–	−5.4005

The Flower Observatory. 1898 *January* 28.

THE CONSTANT OF ABERRATION,

BY C. L. DOOLITTLE.

In view of the present interest in the values of the astronomical constants, this investigation is published somewhat earlier than was intended. The result is preliminary in the sense that it is derived from a limited amount of material which will ultimately be combined with other data, as the work is still in progress and will presumably continue for some years.

The method is that of KÜSTNER (*A.N.* 3015). Four groups of stars were employed, distributed as follows in right-ascension.

I	$5^h\,28^m$ – $7^h\,9^m$	10	pairs
II	12 48 – 14 52	10	"
III	17 19 – 19 26	10	"
IV	21 29 – 23 28	9	"

No observations have been used except where the morning and evening series were obtained on the same night, though in some cases one or both were incomplete.

The observations were assembled in groups, seldom more than ten days in extent, and the means were formed as illustrated by the following example:

	IV			I		
	No.	$\Sigma\varphi$	Σ ab.	No.	$\Sigma\varphi$	Σ ab.
		″	″		″	″
1896 Oct. 7	9	18.01	112.15	9	17.68	−47.57
8	9	16.66	113.34	10	21.09	−53.54
15	9	14.85	121.11	10	20.03	−52.47
Mean Oct. 10	27	1.834	+12.84	29	2.028	− 5.30

The column headed $\Sigma\varphi$ contains the sum of the latitudes given by the nine or ten pairs observed — obviously the seconds only; and that headed Σ ab., the sum of the reductions for aberration.

Subtracting we have

$$\text{IV} - \text{I} \quad -0''.194 \quad +18.14\,x = 0 \quad \text{wt. } 14$$

the weight being computed for each case from the number of observations.

Thus we have the following values:

		″	″	
1896 Oct. 10.0	IV − I	−0.194	+18.14	14
24.5		+0.003	19.17	18
Nov. 1.5		+0.013	19.36	9
16.3		−0.233	18.49	26
Mean		−0.1284	+18.72	
1897 Jan. 30.0	I − II	−0.002	18.61	24
Feb. 21.5		−0.050	19.11	26
Mar. 12		−0.126	17.99	14
Mean		−0.0486	18.68	
May 13.7	II − III	+0.045	12.90	27
27.7		+0.043	13.44	33
Mean		+0.0439	13.20	
July 9.4	III − IV	−0.352	11.61	20
27.2		−0.299	12.18	22
Aug. 5.0		−0.323	12.42	15
12.0		−0.173	12.18	14
23.0		−0.107	11.40	19
Mean		−0.2546	11.93	

Let $y = 20.4451\,x$. Then y is the correction to STRUVE'S constant. Our four means then give us the following equations:

$$\begin{aligned} 0.916\,y &= +0.1284 \\ 0.911\,y &= +0.0486 \\ 0.646\,y &= -0.0439 \\ 0.584\,y &= +0.2546 \\ y &= +0.1268 \\ \text{Struve}\quad & \;\; 20.4451 \end{aligned}$$

Final Value, 20″.572 ±0″.009

The probable error is derived from the value for a single observed latitude. This was found from a discussion of all of the observations to be ±0″.14.

It will be observed that the above value of the aberration-constant is even larger than that deduced from my South Bethlehem observations, 20″.55 (*A.J.* 406); but it appears to be the legitimate outcome of the data.

The Flower Observatory, 1898 *Feb.* 3.

OBSERVATIONS OF VARIABLE STARS — No. 5,

BY WM. E. SPERRA.

103. *T Andromedae.*

This star reached a maximum in 1897 March, but was at that time lost in the sun's rays. I secured three observations on the rise before the star got too low in the west, and six observations on the decline after the star emerged from the sun's rays in the morning sky; the individual observations are given below, and indicate that the maximum occurred about March 17 ±5 days. The date may be useful as a check in computing the elements of the star.

	M		M
1897 Feb. 19	10	1897 Apr. 12	9.0
24	9.9	17	8.8
27	9.6	24	9.2
Mar. 31	8.5	25	9.4
Apr. 4	8.9		

1981. *S Camelopardalis.*

Twenty-three observations of this star, between 1896 Oct. 2 and 1897 March 7, indicate a slight fall from $8^{M}.7$ at first date to $8^{M}.9$ at the end of that month, then an interruption of several weeks occurred in the rise at $8^{M}.4$, and the maximum of $7^{M}.9$ was reached 1897 Jan. 12, after which the decline was steady to $9^{M}.0$ at last observation.

2100. *U Orionis.*

A series of fifteen observations, extending from 1897 February 19 to May 5, indicate as the date of maximum 1897 March 11, at $6^{M}.0$. The rise was rapid and regular, while the decline was slightly irregular. The magnitude at the first and last observations was $7^{M}.0$.

4521. *R Virginis.*

This star was observed thirty-three times between, 1897 February 13 and July 3, resulting in a minimum for 1897 March 16 at $11^{M}.2$, and a maximum for 1897 May 26 at $6^{M}.6$. At the first observation the star was at $10^{M}.0$, and at the last date, $8^{M}.5$.

5157. *S Bootis.*

Eighteen observations, between 1897 March 10 and June 9, indicate a slow rise from $9^{M}.2$ at first date to $9^{M}.0$ about April 5, after which date the rise was rapid to the maximum which occurred 1897 May 2.5 at $7^{M}.8$. The fall was steady to $9^{M}.2$ at last observation.

Randolph, Ohio, 1898 *January* 25.

NEW VARIABLE IN *PUPPIS*.*

$7^{h}\ 26^{m}\ 20^{s}.9$, $-20^\circ\ 21'.4$ (1855),

By ARTHUR C. PERRY.

The star S.DM. $-20^\circ 2007$ announced by me in *A.J.* 398 as probably variable, has proved to be such. It was observed last year, until it was too far west to be further seen, without noting a variation of over half a magnitude. It is now nearly two magnitudes fainter than its brightest phase last year. The position of this star in relation to the variable 2690 *X Puppis* is $9^{s}.1$ preceding, and $14'.7$ north, according to the S.DM. Catalogue.

Brooklyn, New York, 1898 *Feb.* 13.

CONFIRMATION OF VARIABILITY,*

By HENRY M. PARKHURST.

Early in March, 1897, Mr. PERRY requested me to observe S.DM. $-20^\circ 2007$, which he suspected of variability, being two magnitudes brighter than the S.DM. estimate. My observations showed a maximum on 1897 March 17; but as it had only fallen half a magnitude during the few weeks of observation, it was deemed best to wait another year before making the announcement. The star has now fallen two magnitudes, fully establishing its variability.

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* In accordance with the foregoing discovery by Mr. PERRY, and confirmation by Mr. H. M. PARKHURST, the following definitive notation is herewith assigned:

2689 *Z Puppis*, (1900) $7^{h}\ 28^{m}\ 18^{s}$ $-20^\circ\ 26'.7$; (1855) $7^{h}\ 26^{m}\ 21^{s}$ $-20^\circ\ 21'.1$. ED.

ANDERSON'S NEW VARIABLE IN *GEMINI*.*

$6^{h}\ 37^{m}\ 50^{s}.0$, $+30^\circ\ 25'.2$ (1855),

By J. A. PARKHURST.

The variability of this star was announced by ANDERSON in *A.N.* 3463, he finding it $8^{M}.3$, on 1897 Nov. 28. I have the following observations:

		M		M
1898 Jan.	4	9.4	1898 Jan. 26	10.3
	5	9.3	29	10.5
	16	9.7	Feb. 15	10.9
	20	10.0		

The variability thus seems established beyond a doubt.

The following are the positions of the three nearest comparison-stars relative to the variable:

	s	'	M
r	−3.4	−1.2	11
g	−0.5	+0.9	12
d	+8.7	+1.9	10

The reference-point for magnitude is the star *d*, which is estimated by ANDERSON as $10^{M}.0$.

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* The proof of variability warrants the assignment of the following definitive notation:

2404 *X Geminorum*, (1900) $6^{h}\ 40^{m}\ 43^{s}$ $+30^\circ\ 22'.6$: (1855) $6^{h}\ 37^{m}\ 50^{s}$ $+30^\circ\ 25'.2$. ED.

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DOUBLE-STAR MEASURES,

By R. G. AITKEN.

The following measures were made with the 36-inch and 12-inch telescopes of the Lick Observatory. With the former telescope, eyepieces with powers of 1000 and 1500 were used; and with the latter, 500 and 700 power eyepieces. A few exceptions are indicated in the notes.

In observing the eyes were held normal or parallel to the line joining the stars, and four or more independent settings were made for the position-angles, and three or more double-distance settings for the distances. In general, the stars were observed within two hours of the meridian, and measures were only made on nights when the eyepieces mentioned above could be used to advantage.

The columns give in order, the date, position-angle, distance, the seeing (which may also be taken as the weight of the measure, 5 being maximum), and the telescope used.

The positions are for 1900.0 — the less accurate ones being given only to one-tenth minute in right-ascension.

Σ 3062 (6.9 ; 7.5).

$\alpha = 0^h\ 1^m\ 2^s.$; $\delta = +57°\ 53'$

	°	″		
1897.827	333.5	1.63	3	12
.830	333.6	1.43	4	12
.833	334.9	1.45	4	12
1897.83	334.0	1.50		

β 1027 (7.2 ; 10.3).

$\alpha = 0^h\ 9^m\ 46^s$; $\delta = +20°\ 59'$

1897.876	181.5	1.45	3	12
.882	180.6	1.72	4	12
.898	180.5	1.69	4	12
1897.89	180.9	1.62		

Angle apparently diminishing.

h 1968 (7.5 ; 10.2).

$\alpha = 0^h\ 22^m\ 36^s$; $\delta = -16°\ 58'$

1897.709	109.0	2.47	4	12
.712	107.5	2.47	4	12
.745	105.7	2.52	3	12
1897.72	107.4	2.49		

A new discussion of the relative proper motion of this pair by Prof. S. GLASENAPP is published in the *Proc. Russian Astron. Soc.* for April, 1897. From this paper it appears that $\mu = 0''.2753$ in the direction 235°.11, and that the minimum distance, 2″.28, will be reached in 1904.

β 1094 (5.7 ; 9.5).

$\alpha = 0^h\ 24^m\ 45^s$; $\delta = +59°\ 26'$

	°	″		
1897.882	245.0	0.79	4	12
.991	247.7	0.77	3	12
.994	246 1	0.81	4	12
1897.96	246.3	0.79		

No change.

β 395 (6.9 ; 7.2).

$\alpha = 0^h\ 32^m\ 12^s$; $\delta = -25°\ 19'$

1897.909	273.1	0.25	3	36
.912	273.6	0.25	3	36
.932	274.4	0.30	3	36
1897.92	273.7	0.27		

These measures were published in *A.J.* 424.

Σ 60 = η *Cassiopeae* (4 ; 7).

$\alpha = 0^h\ 43^m\ 3^s$; $\delta = +57°\ 17'$

1897.827	210.9	5.10	4	12
.830	210.4	5.13	4	12
.833	211.5	5.09	3	12
1897.83	210.9	5.11		

Σ 73 = 36 *Andromedae* (6.2 ; 6.8).

$\alpha = 0^h\ 49^m\ 37^s$; $\delta = +23°\ 5'$

1897.975	18.0	1.24	2	12
.978	16.6	1.26	3	12
.981	16.8	1.21	4	12
1897.98	17.1	1.24		

β 1161 (6.9 ; 7.7).

$\alpha = 0^h\ 57^m\ 3^s$; $\delta = +51°\ 16'$

	°	″		
1897.830	329.4	0.5 ±	3	12
.978	332.6	0.5 ±	3	12
1897.90	331.0	0.5 ±		

Some change in the angle.

β 235 (7 ; 7 +).

$\alpha = 1^h\ 4^m\ 39^s$; $\delta = +50°\ 29'$

1897.827	87.4	0.86	4	12
.830	88.2	0.84	4	12
.863	87.2	0.89	3	12
1897.84	87.6	0.86		

Angle and distance are both increasing.

OΣ 515 = φ *Andromedae* (5 ; 6).

$\alpha = 1^h\ 3^m\ 42^s$; $\delta = +46°\ 42'$

1897.950	57.0	0.23	2	36
.989	59.4	0.20	3	36
1898.011	52.8	0.26	2	36
1897.98	56.4	0.23		

Seeing not good enough to make the quadrant entirely certain. If correct as here given, the companion has passed through an arc of 250° since 1851.

β 258 (6.3 ; 9.7).

$\alpha = 1^h\, 6^m\, 48^s$; $\delta = +61^\circ\, 11'$

	°	″		
1897.827	258.6	1.04	2	12
.830	256.0	0.87	3	12
.863	255.5	1.12	3	12
1897.84	256.7	1.01		

A 12^M star is situated 41″ from *A* in angle 204°.

β 1100 (7+ : 7+).

$\alpha = 1^h\, 8^m\, 24^s$; $\delta = +60^\circ\, 25'$

1897.863	32.7	0.65	3	12
.978	34.0	0.89	3	12
.991	34.3	0.70	3	12
1897.94	33.7	0.75		

In 1889.54 the angle was $43^\circ.6$, the distance $0''.48$, by β's measures.

β 1229 (8.1 ; 8.4).

$\alpha = 1^h\, 14^m\, 42^s$; $\delta = -35^\circ\, 1'$

1897.882	289.6	1.25	4	12
.991	294.9	1.12	3	12
.994	293.4	1.04	4	12
1897.96	292.6	1.14		

No change.

β 509 (8.4 ; 8.7).

$\alpha = 1^h\, 38^m\, 29^s$. ; $\delta = +9^\circ\, 4'$

1897.882	252.5	0.89	4	12
.898	252.6	0.77	4	12
.978	250.2	0.84	2	12
1897.92	251.8	0.83		

The angle has changed 20° since discovery in 1878.

OΣ 38 = γ *Andromedae, BC* (5.5 ; 7).

$\alpha = 1^h\, 57^m\, 56^s$; $\delta = +41^\circ\, 51'$

1897.950	119.0	0.27	3	36
.989	117.0	0.28	3	36
1898.011	118.3	0.32	2	36
1897.98	118.1	0.29		

Σ 228 (6.7 ; 7.6).

$\alpha = 2^h\, 7^m\, 38^s$; $\delta = +47^\circ\, 1'$

1897.991	78.9	0.63	4	12
.994	75.2	0.65	4	12
1898.005	75.3	0.63	4	12
1898.00	76.5	0.64		

The change in angle since Σ (1831) amounts to 174°.

β 1030 (8+ ; 8+).

$\alpha = 3^h\, 4^m\, 21^s$; $\delta = +21^\circ\, 22'$

1897.882	161.6	0.73	3	12
.898	165.6	0.72	3	12
.978	155.3	0.83	3	12
.981	161.2	[0.7 ±]	3	12
1897.93	160.9	0.76		

Fog stopped work before distance could be measured on the last night. The distance seems to be increasing.

β 1184 (8.4 ; 8.3).

$\alpha = 3^h\, 42^m\, 25^s$; $\delta = +22^\circ\, 4'$

	°	″		
1897.863	262.8	0.77	4	12
.882	270.1	0.74	3	12
.898	265.9	0.69	4	12
1897.88	266.3	0.73		

Slow increase in angle and distance.

OΣ 65 (6.5 ; 7).

$\alpha = 3^h\, 44^m\, 18^s$; $\delta = +25^\circ\, 17'$

1897.863	204.8	0.65	4	12
.898	205.7	0.69	4	12
.912	201.7	0.60	3	36
1897.89	204.1	0.65		

OΣ 74 (8 ; 8+).

$\alpha = 4^h\, 6^m\, 49^s$; $\delta = +9^\circ\, 24'$

1897.950	292.3	0.39	3	36
.989	291.9	0.38	3	36
1898.011	293.0	0.44	2	36
1897.98	292.4	0.40		

Σ 518 = O^2 *Eridani* (10 ; 11).

$\alpha = 4^h\, 10^m\, 49^s$; $\delta = -7^\circ\, 47'$

1897.950	76.0	2.39	3	12
.978	79.4	2.67	2	12
.991	76.3	2.80	3	12
1897.97	77.2	2.62		

Small star very faint on all nights.

OΣ 82 (8.0 ; 8.7).

$\alpha = 4^h\, 17^m\, 4^s$; $\delta = +14^\circ\, 49'$

1897.950	124.3	0.86	3	12
.978	128.3	0.96	2	12
.989	128.2	0.83	3	12
1897.97	126.9	0.88		

A binary in retrograde motion.

β 883 (7+ ; 7+).

$\alpha = 4^h\, 45^m\, 40^s$; $\delta = +10^\circ\, 54'$

1897.715	30.6	0.23	3	36
.731	29.9	0.26	4	36
.797	28.4	0.27	3	36
.909	34.4	0.32	2	36
.912	32.1	0.33	3	36
.950	33.7	0.30	3	36
1897.75	29.6	0.25		
1897.92	33.4	0.32		

The first two of the above measures were published in *A.J.* 415.

As there indicated, the quadrant is indeterminate.

β 552 (6.9 ; 10.2).

$\alpha = 4^h\, 46^m\, 11^s$; $\delta = +13^\circ\, 29'$

	°	″		
1897.715	198.6	0.38	3	36
.731	188.2	0.48	4	36.
.797	191.4	0.44	2	36
.912	197.3	0.46	3	36
.950	193.0	0.46	3	36
1897.82	193.7	0.44		

This star is much more difficult than the preceding one. The second position-angle was wrongly printed in *A.J.* 415. According to the mean position given above the motion is not so rapid as indicated in the note referred to.

OΣ 98 = 14 *i Orionis* (6.0 ; 6.8).

$\alpha = 5^h\, 2^m\, 26^s$; $\delta = +8^\circ\, 22'$

1897.950	172.0	1.28	3	12
.978	175.8	1.14	3	12
.989	176.1	1.12	4	12
1897.97	174.6	1.18		

Slow, retrograde motion. An arc of 75° has been traversed since 1843.

A.C. 3 (7.2 ; 8.7).

$\alpha = 6^h\, 6^m\, 47^s$; $\delta = -4^\circ\, 39'$

1897.950	172.7	1.01	3	12
.989	173.8	0.90	4	12
.994	178.5	0.96	3	12
.997	174.0	1.14	3	12
1897.98	174.8	1.00		

Little or no change.

A.G.C. 1 = *Sirius.*

$\alpha = 6^h\, 40^m\, 44^s$; $\delta = -16^\circ\, 35'$

1897.731	175.9	3.92	5	36
.756	174.4	4.04	3	36
.838	175.8	4.14	5	36
.915	172.8	–	4	36
1897.81	174.7	4.03		

These measures were published in *A.J.* 424. They were all made with a 520-power eyepiece, and with the star near the meridian. Clouds prevented distance measure on the last night.

Σ 1074 (7.8 ; 8.2).

$\alpha = 7^h\, 15^m\, 23^s$; $\delta = +0^\circ\, 35'$

1897.950	141.4	0.77	4	12
.989	136.6	0.81	3	12
.997	147.3	0.72	3	12
1897.98	141.8	0.77		

C, 12^M, is 16″ n. of *AB* in angle 9°.

D, 10^M, is 54″ preceding *AB* in angle 278°.

Slow, direct motion.

Procyon (Schaeberle's companion).

$\alpha = 7^h\,34^m\,7^s \;;\; \delta = +5^\circ\,29'$

	°	″		
1897.838	321.7	4.84	4	36
.876	324.8	4.67	4	36
.915	324.8	4.59	4	36
1897.88	323.8	4.70		

These measures were published in *A.J.* 424. They were made with a 520-power eyepiece.

β 101 = 9 *Argus* (5.7 ; 6.3).

$\alpha = 7^h\,47^m\,18^s \;;\; \delta = -13^\circ\,38'$

1897.833	290.0	0.59	4	12
.835	294.7	0.65	3	12
.868	293.3	0.63	3	36
1897.85	292.7	0.62		

Σ 1196 = ζ *Cancri, AB* (5.5 ; 6.2).

$\alpha = 8^h\,6^m\,29^s \;;\; \delta = +17^\circ\,58'$

1897.833	8.3	1.10	4	12
.835	9.6	1.05	3	12
.868	11.2	1.13	3	12
1897.85	9.7	1.09		

Σ 3121 (7.2 ; 7.5).

$\alpha = 9^h\,11^m\,57^s \;;\; \delta = +29^\circ\,0'$

1897.833	14.3	0.77	4	12
.835	12.6	0.77	3	12
.868	14.9	0.75	3	12
1897.85	13.9	0.76		

Σ 1356 = ω *Leonis* (6 ; 7).

$\alpha = 9^h\,23^m\,6^s \;;\; \delta = +9^\circ\,30'$

1897.833	108.3	0.86	3	12
.835	109.5	0.90	3	12
.868	108.0	0.87	3	12
1897.85	108.6	0.88		

A.C. 5 = 8 *Sextantis* (5½ ; 6).

$\alpha = 9^h\,47^m\,34^s \;;\; \delta = -7^\circ\,38'$

1897.868	91.5	0.39	3	36
.915	91.4	0.39	3	36
1898.022	90.2	0.39	3	36
1897.93	91.0	0.39		

Σ 1523 = ξ *Ursae Majoris* (4 ; 5).

$\alpha = 11^h\,12^m\,51^s \;;\; \delta = +32^\circ\,6'$

1897.989	159.1	2.00	4	12
.997	160.2	2.08	3	12
1897.99	159.6	2.04		

Σ 1670 = γ *Virginis* (3 ; 3.2).

$\alpha = 12^h\,36^m\,36^s \;;\; \delta = -0^\circ\,54'$

1897.948	329.2	5.43	3	12
.997	330.2	5.69	4	12
1897.97	329.7	5.56		

Both of the above are daylight measures, the first being made at 10 A.M., the second just at sunrise.

Σ 1937 = η *Coronae Borealis* (5.5 ; 6).

$\alpha = 15^h\,19^m\,4^s. \;;\; \delta = +30^\circ\,39'$

	°	″		
1897.772	335.0	0.73	3	12
.781	339.2	0.60	3	12
.797	334.4	0.56	4	12
.997	334.5	0.62	4	12
1897.84	335.8	0.63		

Σ 1938 = μ² *Bootis* (6.5 ; 8).

$\alpha = 15^h\,20^m\,44^s \;;\; \delta = +37^\circ\,43'$

1897.781	75.1	0.67	3	12
.797	79.1	0.94	4	12
.997	76.5	0.89	4	12
1897.86	76.9	0.83		

*O*Σ 298 (7 ; 7.4).

$\alpha = 15^h\,32^m\,30^s \;;\; \delta = +40^\circ\,9'$

1897.781	174.4	1.01	3	12
.797	175.6	1.18	4	12
.997	180.6	1.15	4	12
1897.86	176.9	1.11		

Σ 2032 = σ *Coronae Borealis* (6 ; 7).

$\alpha = 16^h\,10^m\,56^s \;;\; \delta = +34^\circ\,7'$

1897.770	209.9	4.42	3	12
.772	209.7	4.26	3	12
.781	210.0	4.25	4	12
1897.77	209.9	4.31		

β 1249 (8.8 ; 9).

$\alpha = 17^h\,19^m\,56^s \;;\; \delta = +53^\circ\,57'$

1897.709	82.3	0.46	4	12

Very difficult. *C*, 9ᴹ, follows in 74°.3, distance 60″.

β 1250 (9+ ; 9+).

$\alpha = 17^h\,21^m\,5^s \;;\; \delta = +30^\circ\,50'$

1897.704	65.0	1.93	3	12
.709	63.9	2.05	4	12
.712	65.9	2.00	4	12
1897.71	64.9	1.99		

No certain change.

β 1121 (8.5 ; 9.0).

$\alpha = 17^h\,32^m.8 \;;\; \delta = +12^\circ\,36'$

1897.704	242.5	0.66	3	12
.709	238.5	0.62	4	12
.712	241.4	0.63	4	12
1897.71	240.8	0.64		

Unchanged.

β 1202 (8.2 ; 9.8).

$\alpha = 17^h\,56^m\,37^s \;;\; \delta = +3^\circ\,33'$

1897.712	341.1	0.76	4	12
.729	346.6	0.87	3	12
.745	351.2	0.83	3	12
1897.73	346.3	0.82		

Faint and difficult on all nights.

β 1127 (7.8 ; 9.7).

$\alpha = 17^h\,59^m\,34^s \;;\; \delta = +44^\circ\,14'$

	°	″		
1897.704	128.2	0.89	3	12
.709	128.4	0.86	4	12
.729	134.8	0.89	3	12
1897.71	130.5	0.88		

Considerable change in angle. β in 1889.53 found 144°.7.

Σ 2272 = 70 *Ophiuchi* (4.5 ; 6).

$\alpha = 18^h\,0^m\,24^s \;;\; \delta = +2^\circ\,31'$

1897.827	276.6	2.01	3	12
.833	275.5	1.91	4	12
.835	278.1	1.87	3	12
1897.83	276.7	1.93		

β 641 (7.3 ; 9.0).

$\alpha = 18^h\,17^m\,34^s \;;\; \delta = +21^\circ\,28'$

1897.693	340.8	1.00	3	12
.709	344.2	0.93	4	12
.712	341.8	0.98	4	12
1897.70	342.3	0.97		

Slow retrograde motion.

β 648 (6.0 ; 9.2).

$\alpha = 18^h\,53^m\,16^s \;;\; \delta = +32^\circ\,46'$

1897.693	228.1	1.35	3	12
.709	231.1	1.43	4	12
.712	230.1	1.22	4	12
1897.70	229.8	1.33		

Probably binary, but the form of the orbit is still uncertain. The only other measures I can find are

1878.47	312.5	0.61	β	2*n*
79.47	298.3	0.66	β	1
91.33	247.7	1.26	β	3
92.38	245.6	1.29	β	5
95.59	237.9	1.49	Lewis	3
1896.49	231.5	1.34	Aitken	3

Σ 2438 (7.2 ; 7.3).

$\alpha = 18^h\,55^m\,49^s \;;\; \delta = +58^\circ\,5'$

1897.797	29.2	0.30	3	36
.833	30.9	0.31	4	36
.838	31.1	0.29	3	36
1897.82	30.4	0.30		

This star has nearly completed one revolution since the first measure by Herschel in 1783.

Δ 19 = *Cygni* 4 (7.9 ; 9.4).

$\alpha = 19^h\,6^m\,17^s \;;\; \delta = +55^\circ\,10'$

1897.693	19.1	0.82	3	12
.709	13.3	0.83	4	12
.729	18.0	0.84	3	12
1897.71	16.8	0.83		

Küstner 2 (7.2 ; 9.2).

$\alpha = 19^h\,35^m\,26^s$; $\delta = +71^\circ\,23'$

	°	″		
1897.693	263.3	1.39	3	12
.709	264.1	1.22	4	12
.729	258.5	1.29	4	12
1897.71	262.0	1.30		

In 1889.27 β found 271°.1, 1″.44. I know of no other measures.

β 146 (8.1 ; 9.2).

$\alpha = 19^h\,41^m.3$; $\delta = -20^\circ\,7'$

1897.729	306.2	1.07	3	12
.737	306.6	1.35(½wt)	2	12
.745	304.7	0.97	3	12
1897.74	305.8	1.09		

β 1133 (6.8 ; 9.5).

$\alpha = 19^h\,55^m\,41^s$; $\delta = +31^\circ\,33'$

1897.770	337.0	1.04	2	12
.781	336.4	0.87	4	12
.827	332.4	0.87	2	12
1897.79	335.3	0.93		

No certain change.

β 1258 (8.0 ; 10.8).

$\alpha = 19^h\,56^m\,15^s$; $\delta = +29^\circ\,39'$

1897.770	153.8	1.60	3	12
.781	156.1	1.50	4	12
.827	151.9	1.57	3	12
1897.79	153.9	1.56		

The angle is slowly diminishing without much change in the distance.

β 1205 (8.1 ; 9.4).

$\alpha = 20^h\,6^m\,51^s$; $\delta = -8^\circ\,23'$

1897.704	48.6	0.70	3	12
.709	42.9	0.67	3	12
.729	48.4	0.73	3	12
1897.71	46.6	0.70		

Change doubtful.

OΣ 400. (7.3 ; 7.7).

$\alpha = 20^h\,6^m\,55^s$; $\delta = +43^\circ\,39'$

1897.605	47.6	0.20	3	36
.797	46.0	0.19	3	36
.830	48.2	0.22	3	36
1897.74	47.3	0.20		

β 1206 (7.8 ; 10.8).

$\alpha = 20^h\,15^m\,21^s$; $\delta = +36^\circ\,27'$

1897.781	354.7	2.25	3	12
.876	356.6	—	2	12
1897.83	355.6	2.25		

Small star very faint. The angle seems to be diminishing.

β 1135 (8.3 ; 10.7).

$\alpha = 20^h\,25^m\,50^s$; $\delta = +45^\circ\,24'$

1897.781	340.4	1.56	4	12

β 151 = β *Delphini*. (4 ; 6).

$\alpha = 20^h\,32^m\,52^s$; $\delta = +14^\circ\,15'$

	°	″		
1897.518	360.2	0.73	4	12
.523	355.0	0.73	1	12
.614	353.8	0.59	3	12
1897.55	356.3	0.68		

OΣ 413 = λ *Cygni*. (5 ; 7).

$\alpha = 20^h\,43^m\,31^s$; $\delta = +36^\circ\,7'$

1897.835	66.2	0.64	3	36
.854	67.1	0.64	3	36
.876	64.0	0.58	2	36
1897.85	65.8	0.62		

β 1034 = 7 *Aquarii*. (6.0 ; 11.7).

$\alpha = 20^h\,51^m\,30^s$; $\delta = -10^\circ\,5'$

1897.704	165.0	2.14	4	12
.709	163.3	—	3	12
.745	162.8	1.97	3	12
1897.72	163.7	2.05		

No change since β's measure in 1888.

β 1211 (7.5 ; 8.1).

$\alpha = 20^h\,58^m\,23^s$; $\delta = -18^\circ\,30'$

1897.704	347.6	0.67	3	12
.709	347.5	0.66	4	12
.745	347.7	0.67	3	12
1897.72	347.6	0.67		

Change uncertain.

Secchi BC (9 ; 9).

$\alpha = 20^h\,59^m\,43^s$; $\delta = +3^\circ\,8'$

1897.693	150.7	1.12	2	12
.709	150.6	1.18	4	12
.729	119.6	0.98	3	12
1897.71	150.3	1.09		

A and *BC* = Σ 2749.

1897.693	155.6	3.09	2	12

Küstner 2 = γ *Equulei* (4.2 ; 11).

$\alpha = 21^h\,5^m\,29^s$; $\delta = +9^\circ\,44'$

1897.772	271.6	2.29	2	12
.781	273.2	2.24	3	12
.854	273.6	2.64	2	36
.863	274.2	2.42	3	12
1897.82	273.2	2.40		

Third distance-measure hurried.

OΣ 535 = δ *Equulei* (4.5 ; 5.0).

$\alpha = 21^h\,9^m\,37^s$; $\delta = +9^\circ\,37'$

1897.781	208.8	0.36	4	12
.830	204.6	0.30	4	36
.854	208.6	0.36	3	36
.863	216.2	0.30	3	12
1897.83	209.6	0.33		

The 12-inch measures were made with a 900-power eyepiece.

β 1261 (8.5 ; 9.7).

$\alpha = 21^h\,11^m\,25^s$; $\delta = +15^\circ\,41'$

	°	″		
1897.781	148.0	1.60	3	12
.863	148.4	1.62	3	12
.876	148.3	1.50	3	12
1897.84	148.2	1.57		

Probably unchanged.

β 838 (8.3 ; 9.2).

$\alpha = 21^h\,15^m\,52^s$; $\delta = +2^\circ\,42'$

1897.734	95.0	1.34	3	12
.737	91.1	1.56	3	12
.745	95.3	1.27	3	12
1897.74	93.8	1.39		

OΣ 435 (8.4 ; 8.5).

$\alpha = 21^h\,16^m\,20^s$; $\delta = +2^\circ\,28'$

1897.734	213.9	0.80	3	12
.737	213.0	0.77	3	12
.745	216.8	0.70	3	12
1897.74	214.6	0.76		

β 1262 (8.3 ; 9.0).

$\alpha = 21^h\,16^m.8$; $\delta = -15^\circ\,21'$

1897.704	112.3	2.02	3	12
.712	110.7	1.94	4	12
.734	113.8	1.97	3	12
1897.72	112.3	1.98		

Change doubtful.

β 72 (8.3 ; 8.9).

$\alpha = 21^h\,24^m.8$; $\delta = -5^\circ\,50'$

1897.734	36.0	1.94	2	12
.737	40.4	1.93	3	12
.745	36.5	1.80	3	12
1897.74	37.6	1.89		

Angle slowly diminishing; distance unchanged.

β 684 (8.7 ; 8.9).

$\alpha = 21^h\,24^m.9$; $\delta = -5^\circ\,52'$

1897.737	125.1	1.17	3	12
.745	123.8	1.21	3	12
.767	125.5	1.10	2	12
1897.75	124.8	1.16		

Angle is slowly diminishing.

β 1212 = 24 *Aquarii* (6.3 ; 7.1).

$\alpha = 21^h\,34^m\,22^s$; $\delta = -0^\circ\,30'$

1897.772	264.6	0.63	3	12
.781	263.8	0.75	4	12
.863	262.1	0.58	3	12
1897.81	263.5	0.65		

β in 1890.75 found 254°.5, 0″.45.

β 1036 (8.0 ; 11.0).

$\alpha = 21^h\ 42^m\ 5^s$; $\delta = -17°\ 45'$

	°	″		
1897.704	204.8	4.53	3	12
.712	207.4	4.70	4	12
.734	203.1	5.05	2	12
1897.72	205.1	4.76		

No change.

β 75 (8.1 ; 8.3).

$\alpha = 21^h\ 50^m\ 38^s$; $\delta = +10°\ 25'$

1897.781	39.9	1.04	3	12
.830	39.6	1.01	3	12
.863	39.0	1.22	3	12
1897.82	39.5	1.09		

Apparently no change since 1891.

β 172 = 51 *Aquarii* (5.6 ; 6.0).

$\alpha = 22^h\ 18^m\ 54^s$; $\delta = -5°\ 21'$

1897.704	5.8	0.73	3	12
.709	4.0	0.72	4	12
.712	6.1	0.74	4	12
1897.71	5.3	0.73		

Slow retrograde motion.

β 382 (7.3 ; 8.8).

$\alpha = 22^h\ 49^m\ 12^s$; $\delta = +44°\ 13'$

	°	″		
1897.830	220.4	1.12	3	12
.863	220.9	1.08	4	12
.876	222.3	1.01	3	12
1897.86	221.2	1.07		

Slow direct motion.

β 1025 (8.0 ; 10.8).

$\alpha = 23^h\ 2^m\ 48^s$; $\delta = +12°\ 8'$

1897.781	268.7	0.84	3	12
.830	273.0	0.87	3	12
.863	272.4	0.93	4	12
1897.82	271.4	0.88		

A 12^M-star follows A in 82°, 22″.4.

The only other measure is by β in 1891.57; 268°.6, 0″.77.

β 79 (8.0 ; 8.6).

$\alpha = 23^h\ 12^m\ 28^s$; $\delta = -2°\ 5'$

1897.704	84.8	0.90	3	12
.709	87.4	1.04	4	12
.712	86.9	1.00	4	12
1897.71	86.4	0.98		

The angle is diminishing. The two stars have a common proper motion of 0″.212 in 119°.7.

β 720 = 72 *Pegasi* (6 ; 6).

$\alpha = 23^h\ 28^m\ 59^s$; $\delta = +30°\ 46'$

	°	″		
1897.932	158.6	0.38	3	36

β 858 (8.0 ; 8.2).

$\alpha = 23^h\ 36^m\ 18^s$; $\delta = +32°\ 0'$.

1897.863	261.1	0.70	4	12
.876	264.5	0.69	3	12
.882	262.1	0.72	3	12
1897.87	262.6	0.70		

β 733 = 85 *Pegasi* (6 ; 11.2).

$\alpha = 23^h\ 56^m\ 57^s$; $\delta = +26°\ 33'$

A and *B*.

1897.548	206.4	0.60	2	36
.731	213.1	0.77	5	36
.868	210.1	0.73	3	36
1897.72	209.9	0.70		

A and *C* (6.0 ; 9.0).

1897.534	346.3	31.36	2	36
.597	345.9	31.62	2	36
1897.56	346.1	31.49		

A and *D* (— ; 13.2).

1897.534	288.0	81.98	2	36
.597	288.1	81.80	2	36
1897.56	288.0	81.89		

Measures of *C* and *D* made with 520-power eyepiece.

Lick Observatory, University of California, 1898 *January* 21.

NOTE ON THE VALUE OF THE ABERRATION-CONSTANT DERIVED FROM KÜSTNER'S OBSERVATIONS OF 1884–1885,

BY SIMON NEWCOMB.

In number 427 of the *Astronomical Journal*, CHANDLER mentions a large difference between the values of the aberration-constant which he himself and I derived from KÜSTNER's work of 1884–1885 at Berlin. I derived 20″.46, while he derives 20″.61. I did not re-discuss KÜSTNER's original observations, but used the final equations given by him (*Astr. Nachr.*, Vol. 125, s. 276) as the final outcome of his work. These equations are as follows. The value of $\Delta\varphi$ which follows each equation is taken from CHANDLER's curves in the *Astronomical Journal*.

$$\begin{array}{llll} 1884.32 & \varphi = \overset{''}{16.73} & -0.82\,\Delta A & \Delta\varphi = \overset{''}{-0.10} \\ 1884.70 & 16.96 & +0.83 & +0.20 \\ 1885.31 & 16.52 & -0.85 & -0.21 \end{array}$$

Supposing the mean latitude φ_0 corrected by these amounts KÜSTNER's three equations may be put in the form

$$\begin{aligned} \varphi_0 \ +0.82\,\Delta A &= \overset{''}{16.83} \\ \varphi_0 \ -0.83\,\Delta A &= 16.76 \\ \varphi_0 \ +0.85\,\Delta A &= 16.73 \end{aligned}$$

Hence we have as the result of his work,

$$\begin{aligned} \Delta A &= +\ \overset{''}{0.013} \\ A &= \ \ 20.46 \end{aligned}$$

I have not re-examined the work; it is so simple that any error in it can readily be detected.

NOTE BY THE EDITOR.

In the note accompanying the above article, the author courteously suggests that I add some comments, which accordingly I take the liberty to do. The article makes the source of the difference, between the values of the aberration deduced by Prof. NEWCOMB and myself from KÜSTNER's observations, very clear. He has used apparently the values of the latitude-variation given in my provisional discussion of 1892 instead of my definitive values of 1894. These are given below under I and II, respectively, for the period in question.

Berlin date	$\Delta\varphi$ I	$\Delta\varphi$ II	Berlin date	$\Delta\varphi$ I	$\Delta\varphi$ II
	″	″		″	″
1884.2	−0.21	−0.31	1884.9	+0.13	+0.22
84.3	− .16	− .28	85.0	+ .01	+ .07
84.4	− .04	− .16	85.1	− .10	− .09
84.5	+ .07	.00	85.2	− .19	− .23
84.6	+ .16	+ .17	85.3	− .22	− .28
84.7	+ .21	+ .28	85.4	− .16	− .25
1884.8	+0.21	+0.30	1885.5	−0.13	−0.06

From II we find,

$$\Delta\varphi\ ,\ (1884.32) - 0''.26\ ,\ (1884.70) + 0''.28\ ,\ (1885.31) - 0''.28$$

If these values be substituted in Prof. Newcomb's equations above we shall get 20″.572 for the aberration.

My mode of deriving the value 20″.61 was as follows: The absolute terms in Küstner's equations of condition, pp. 38–44 of his memoir, were corrected by $-2\Delta\varphi$, according to II above. Then, solving the normals anew, I obtained for the corrections to Struve's constant, from the several pairs,

Pair	ΔA	p
	″	
1	+0.167	117.8
2	− .007	60.5
3	+ .077	67.6
4	+ .071	81.7
5	+ .225	129.6
6	+ .257	104.1
7	+0.232	105.3

The mean correction is +0″.166; whence the aberration 20″.611, which is not essentially discordant from the 20″.572 found by Prof. Newcomb's process above, and is, I think, to be preferred.

It should be observed that the date of these observations closely precedes the interval 1889–98, and the formula used for the latitude-variation represents the numerous accurate series of observations during this interval, as well as others coincident with Küstner's, with very great fidelity. Therefore there can be very little uncertainty attaching to the aberration 20″.61 found from this series of Küstner, so far as the corrections applied for latitude-variation are concerned. How much error has been introduced into Mr. Loewy's mean value of the aberration, by his use of 20″.31 for this determination, cannot of course be told until his investigation is published. It is hoped, in the interest of astronomical truth, that this publication will not be longer delayed. There are other determinations that Mr. Loewy has probably used which are affected seriously by the same cause and in the same direction of error. The same is true of Prof. Newcomb's class *B*, pp. 137–9 of his *Astronomical Elements and Constants*, where similar discordances exist between his values and my own unpublished investigations, which may probably be traced to a source like this in Küstner's series, here discussed and happily explained, I trust to Prof. Newcomb's satisfaction. With regard to the latter's class *A* (p. 137 *ibid.*) since Prof. Newcomb has there directly employed my published results, given in *A.J.* 287, 293, 296, 297 and 298, for the eight series of Pulkowa observations, no further discussion can arise as to them.

C.

NOTE ON MR. G. W. HILL'S "OBSERVATIONS" IN *A.J.* 428,

By SIMON NEWCOMB.

The careful reader who compares Mr. Hill's "observations" with the *Procès-verbaux* of the Paris Conference, and with my paper, will see that his argument is based entirely on misconceptions. The Conference said nothing about any 32 stars as constituting the system N_1, and proposed no deviation whatever from the custom of astronomers that has prevailed for nearly a century. As the inconsistencies which he finds in my remarks are inconsistencies only with his constructions I need say nothing about them.

In the remainder of his paper Mr. Hill bases an elaborate argument on the major premise that a discrepancy between two results can be cured by diminishing the lesser one of the two. If, as he maintains, the general motion of the system N_1 in right-ascension, by adopting which I found a correction of +0″.36 to the precessional motion, should be diminished by 0″.98, then, it seems to me, the motion of precession should be diminished by this amount, instead of being increased. If I am right in this the results of Mr. Hill's argument should be,

Correction to luni-solar precession from R.A.,					″ −0.71
"	"	"	"	" Decl.,	+1.43

As to the reality of the negative correction to the motion of N_1 in right-ascension I shall only remark that the basis of the correction +0″.30, which I found in *A.J.*, XIV, p. 187, embodies, if I am not mistaken, all the best part of the material used by Mr. Hill, and a great deal more. I therefore regard this result as the most probable one at present, and see nothing to alter in the discussion found on p. 71 of my paper.

OBSERVATIONS OF ASTEROIDS AND COMET *b* 1897,

MADE WITH THE 12-INCH EQUATORIAL OF THE U.S. NAVAL OBSERVATORY,

By Prof. E. FRISBY, U.S.N.

[Communicated by Prof. Wm. Harkness, U.S.N., Astronomical Director.]

1897-98 Washington M.T.	*	No. Comp.	Planet — * $\Delta\alpha$	Planet — * $\Delta\delta$	Planet's Apparent α	Planet's Apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
			(11) *Parthenope.*					
1897	h m s		m s	′ ″	h m s	° ′ ″		
Sept. 24	10 16 29.0	1	15 , 3	+1 33.45	+ 2 48.6	1 13 27.97	− 0 11 20.7	*n*9.492	0.744
27	11 45 38.7	2	20 , 4	+1 39.91	− 9 3.6	1 10 59.18	− 0 32 10.1	*n*9.049	0.655
29	12 0 17.0	3	14 , 4	−2 12.12	+13 34.5	1 9 19.85	− 0 45 44.9	*n*8.809	0.818

1897-98 Washington M.T.	*	No. Comp.	Planet — * $\Delta\alpha$	Planet — * $\Delta\delta$	Planet's Apparent α	Planet's Apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
(11) *Parthenope.*								
1897 Sept. 24 10h 16m 29.0s	1	15 , 3	+1m 33.45s	+ 2′ 48.6″	1h 13m 27.97s	− 0° 11′ 20.7″	*n*9.492	0.744
27 11 45 38.7	2	20 , 4	+1 39.91	− 9 3.6	1 10 59.18	− 0 32 10.1	*n*9.049	0.655
29 12 0 17.0	3	14 , 4	−2 12.12	+13 34.5	1 9 19.85	− 0 45 44.9	*n*8.809	0.818
(171) *Ophelia.*								
Oct. 4 11 16 7.2	4	20 , 4	−1 22.03	− 2 41.7	1 16 5.89	+ 4 9 47.4	9.051	0.701
(6) *Hebe.*								
Nov. 19 12 21 27.3	5	20 , 4	+0 25.03	+ 0 32.3	5 13 43.98	− 2 37 58.3	*n*8.947	0.766
(61) *Danäe.*								
Nov. 23 13 20 5.6	6	10 , 2	−1 50.21	−10 30.7	5 55 29.66	+48 38 34.5	*n*8.834	*n*0.182
27 8 43 48.2	7	15 , 3	−1 15.98	− 5 42.6	5 51 25.16	+48 46 40.0	*n*9.816	0.265
Dec. 1 10 40 22.1	8	10 , 2	−0 55.64	− 7 38.9	5 46 41.41	+48 51 25.8	*n*9.655	*n*9.509
12 8 58 42.9	9	13 , 4	−0 25.43	−15 53.6	5 32 56.49	+48 43 23.6	*n*9.291	*n*0.124
15 10 6 46.7	10	12 , 3	−5 2.58	+10 48.1	5 29 0.27	+48 35 30.7	*n*9.476	*n*0.005
30 10 22 30.8	11	10 , 2	+0 20.48	+11 11.4	5 11 17.81	+47 24 25.8	*n*9.441	*n*0.125
(247) *Eukrate.*								
1898 Jan. 8 9 55 16.6	12	20 , 4	−3 1.93	+ 0 3.8	7 51 20.30	+62 28 32.2	*n*9.811	*n*0.320
13 7 11 23.9	13	20 , 4	+4 25.33	+ 7 44.9	7 41 41.75	+62 10 18.2	*n*9.974	*n*9.900
20 10 20 28.1	14	4 , 1	−4 22.88	+ 2 3.7	7 28 26.84	+61 21 24.3	*n*8.380	*n*0.532
(65) *Cybele.*								
Jan. 21 11 24 21.3	15	7 , 2	−1 4.60	+ 3 49.7	7 34 12.77	+18 21 43.3	*n*7.886	0.487
28 9 41 21.6	16	19 , 4	−0 18.54	+ 6 32.2	7 29 10.30	+18 38 3.6	*n*9.192	0.498

Comet *b*, 1897.

1897 Washington M.T.	*	No. Comp.	☄ — * $\Delta\alpha$	☄ — * $\Delta\delta$	☄'s apparent α	☄'s apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ
Oct. 18 11h 8m 3.9s	17	20 , 4	−1m 23.34s	+ 5′ 54.8″	3h 23m 45.89s	+69° 46′ 49.7″	*n*9.893	*n*0.522

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
1	1h 11m 50.20s	+4.32s	− 0° 14′ 38.5″	+29.2″	Copeland-Börgen 262–3
2	1 9 14.92	+4.35	− 0 23 35.7	+29.2	“ “ 256–7
3	1 11 27.56	+4.41	− 0 59 49.1	+29.7	“ “ 260
4	1 17 23.47	+4.45	+ 4 11 59.8	+29.3	Albany A.G. Catal. 373
5	5 13 14.20	+4.75	− 2 38 44.3	+13.7	Weisse's-Bessel 5h243
6	5 57 12.67	+7.20	+48 49 4.4	+ 0.8	Bonn A.G. Catal. 4964
7	5 52 33.77	+7.37	+48 52 20.7	+ 1.9	“ “ “ 4887
8	5 47 29.54	+7.51	+48 59 1.4	+ 3.3	“ “ “ 4818
9	5 33 14.18	+7.74	+48 59 9.6	+ 7.6	“ “ “ 4637
10	5 33 55.15	+7.70	+48 24 34.6	+ 8.0	“ “ “ 4645
11	5 10 49.66	+7.67	+47 12 58.9	+15.5	“ “ “ 4315
12	7 54 17.29	+4.94	+62 28 33.0	− 4.6	Hels. and Gotha A.G. Catal. 5340
13	7 37 11.44	+4.98	+62 2 34.8	− 1.5	“ “ “ “ “ 5204
14	7 32 44.74	+4.98	+61 19 22.6	− 2.0	“ “ “ “ “ 5170
15	7 35 14.58	+2.79	+18 17 57.6	− 4.0	Berlin A.G. Catal. 2966
16	7 29 26.04	+2.80	+18 31 34.0	− 2.6	“ “ “ 2914
17	3 25 0.13	+9.10	+69 40 42.0	+12.9	Christiania A.G. Catal. 604

OBSERVATIONS OF THE SATELLITE OF *NEPTUNE*,

By J. M. SCHAEBERLE.

The present series of observations forms the continuation of the results published in No. 392 of the *Astronomical Journal.* Each tabulated position-angle depends on the mean of five separate settings, and each distance on the mean of ten measures. With one or two exceptions, a power of 800 diameters was always used.

Date	Pac. Standard Time	Position Angle	Distance	Remarks	Date	Pac. Standard Time	Position Angle	Distance	Remarks
1897	h m s	°	″		1897	h m s	°	″	
Sept. 13	14 43 30	278.18	14.77		Nov. 15	10 52 22	52.59	15.55	
	15 1 9					11 5 33			
	15 20 33	276.96				11 19 40	52.02		
Sept. 18	15 25 34	342.34	10.10	Clouds prevented further observations	Nov. 27	11 25 46	39.13	13.59	
	15 39 32					11 40 10			
	. . .	. .				. . .	. .		
Oct. 16	12 22 50	74.37	16.69		Nov. 29	9 48 43	260.64	16.72	Cloudy Satellite very faint
	12 38 1					10 34 31			
	12 53 46	74.05				10 54 18	258.92		
Oct. 18	12 18 55	299.40	12.40		Dec. 3	11 23 14	31.16	13.04	
	12 33 15					11 37 36			
	12 46 2	298.38				11 51 44	30.20		
Oct. 29	12 34 36	7.52	10.95		Dec. 11	8 23 8	253.51	17.16	Poor seeing Windy and foggy
	12 46 5					8 40 39			
	12 59 52	5.70				8 59 18	252.19		
Oct. 30	11 20 13	287.19	13.86		Dec. 24	8 3 53	190.87	10.98	Poor seeing Telescope swaying
	11 33 11					8 16 55			
	11 44 19	285.63				8 32 8	188.49		
Nov. 1	11 44 21	184.84	10.93	Telescope swaying	Dec. 25	10 25 54	99.78	14.49	Telescope swaying
	11 57 50					10 40 38			
	12 12 22	183.42				10 56 30	99.66		
Nov. 12	11 25 18	233.81	15.74		Dec. 27	7 59 34	4.54	11.17	
	11 38 30					8 11 44			
	11 50 46	232.85				8 28 50	2.96		

Lick Observatory, University of California, 1898 *Jan.* 3.

CORRECTION,

By G. W. HILL.

Prof. Newcomb has pointed out to me that the corrections of equinox-velocity, $-0^s.064$ and $-0^s.069$, at p. 155 of my article on Precession, have the wrong sign for harmonizing his two values of this element. The correction of my ludicrous inadvertence as to their proper signs, of course, deprives them of much of their interest. However, their failure to reconcile the values of precession severally from right-ascensions and declinations does not prove them illegitimate deductions from observation; for this turns solely upon the point whether Auwers's equinox for Bradley is to be preferred to Bessel's, and whether it is good judgement to reject Piazzi and Maskelyne. The investigation may be regarded as showing that the problem of deducing a precession-constant satisfactory in regard to both stellar coordinates is more difficult even than appears from Prof. Newcomb's treatment.

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THE PRECESSIONAL MOTION AND THE PARIS CONFERENCE (THIRD PAPER),

BY LEWIS BOSS.

IN HIS recent article on the precessional motion (*A.J.* 426) Professor NEWCOMB disclaims in the strongest manner any desire to force the conclusion that his work on precession ought to be generally adopted. But he still appears totally to misunderstand the point at issue. I must, therefore, crave indulgence for attempting once more to make my view intelligible to others, since it is evident that I have not hitherto succeeded.

Long ago it became evident that astronomers, generally, were not satisfied with the conclusions of the Paris Conference. Yet, to many, submission to those conclusions seemed to be a necessity, because one or the other of the four Almanacs which had joined in the adoption of these new constants would have to be used by astronomers. To them there seemed to be no alternative. With very great reluctance, I then decided to raise the question, whether the decisions of the Paris Conference ought to stand for astronomers in general; and I then endeavored to advocate the acceptance of two points:

First, that the conclusions of the Conference, even in right of courtesy, were of no more binding force than would be the conclusions of any self-constituted Conference; as, for instance, if the directors of any four observatories should meet on their own motion and formulate their conclusions. I even pointed out another fact which was likely to be overlooked by some. I did not accuse the Conference of "assuming to legislate for astronomers" as Professor NEWCOMB now says I did; on the contrary, I said that, in my opinion, the Conference did not pretend so to legislate. Consequently, it did not even make a claim upon our acceptance of its conclusions, otherwise than by implication. It is a fact that those conclusions did exert a strong pressure, because they were to be adopted by the four Almanacs and non-acceptance of the Almanacs might entail a very great inconvenience. Accordingly, I expressed the opinion that we ought to endure any inconvenience rather than to suffer the establishment of a precedent so hurtful to the best interests of Science. My whole contention has been that astronomers should not sleepily acquiesce in what they do not approve under a mistaken notion that courtesy requires it, or under the lash of necessity. The personal participation of this astronomer, or of that one, had nothing whatever to do with the matter.

Secondly, I endeavored to show that the time is not ripe for the general adoption of new elements of aberration and precession. Here, again, Professor NEWCOMB totally misapprehends my meaning in one particular, at least. I sincerely apologize for my lack of clearness on this point, which appears to arise primarily out of my use of the word "definitive." That term has come to have a special meaning in astronomical computation. At least, I used it as nearly synonymous with "exhaustive," or "comprehensive," — meaning that such a computation should embrace all really useful evidence on the point. In this sense there may be any number of definitive, and especially of what I have termed "intentionally definitive," computations. That would be a sad day for sidereal astronomy when astronomers unanimously decide to consider any particular value of the precessional motion "definitive," in the sense of absolute and final. While I most sincerely regret that Professor NEWCOMB ever looked forward to such a time, I congratulate him on having outgrown that idea (*A.J.* 426, p. 138, col. 1).

Passing now to the consideration of the points in which Professor NEWCOMB denies the correctness, or value, of my opinions and statements, I must apologize for the length of this reply, though I shall make it as brief as possible. This great length is rendered necessary because I am not permitted to set up my unsupported personal judgement against the great authority of Professor NEWCOMB. I have, however, freely admitted the many great merits of his work on the precessional motion (*A.J.* No. 410); so that it is not necessary for me, in answer to his complaints (*A.J.* 426), to expand this article by enumerating those merits in detail. There are also many minor points which need not be further considered.

After all, the essential differences between our respective views are few in number. Professor Newcomb concedes nearly all I claim, but differs from me on what, at first sight, seem to be mere matters of detail. These differences, however, can be reduced to a single essential difference. He thinks that a rough, summary and partial discussion of the precessional motion, such as he has produced, good enough to answer all needs during the first half of the next century; while I think that astronomers are entitled to have a work which shall essentially summarize all the really useful testimony which can readily be brought to bear; and I think that this embraces far more than he has employed. But I am far from wishing to raise this demand to an unreasonable pitch. It only seems to me a pity to let the greater part of the volumes containing the results of skillful and laborious meridian observations moulder on our library shelves on the plea that two or three of them are all that are really needed for the advancement of astronomy.

For the greater part of what I consider essential to my reply I must refer the reader to my articles in Nos. 410 and 423. The following heads are simply amplifications of my views, there expressed, upon four of the points in reference to which Professor Newcomb interposes his objections; and of these four there is space only to consider the third, and most important, with any degree of technical detail.

I. Personal Equation Dependent upon Magnitude.

Professor Newcomb still insists that he cannot see how, for any precise purpose, we can make any use of the right-ascensions of faint stars determined by the older observers.

It is, of course, impossible here to cover the ground required in a full and proper discussion of this subject. I have already pointed out (*A.J.* 423) some of the many reasons why I think that eye-and-ear transits are not usually much affected by a personal equation dependent on magnitude. If this equation were equally liable to have positive or negative values, then Professor Newcomb's objection would practically fall to the ground. But on what I consider insufficient premises he thinks that the sign of this equation in eye-and-ear observations of faint stars is nearly if not quite always negative, as with chronographic registry.

We have a means of examining this question for the older observations, which I here briefly suggest through an example. I have compared the Albany zone with those of Lalande, Bessel, Schjellerup, and others. In making this comparison I have corrected the Albany observations for personal equation dependent on magnitude, and have arranged the comparisons in groups according to brightness of the stars compared. The comparisons have been corrected for systematic errors (same for all groups in a given set) in the manner explained in Nos. 195–6 of this Journal.

Alb.-Lal.		Alb.-Bessel		Alb.-Schj.	
Mag.	$\Delta\alpha$	Mag.	$\Delta\alpha$	Mag.	$\Delta\alpha$
	s		s		s
6.5	−0.05	6.0	−0.02	7.5	−0.023
		7.7	−0.03	8.4	−0.022
8.7	−0.04	8.9	−0.00	9.0	−0.025

The range of star-magnitude here brought into comparison is very small, and it is evident that results of no great precision can be reached by the use of the material contained in a zone only 4° wide; but so far as it goes it exhibits, if anything, a *positive* equation for the older observers, though this tendency is too slight to possess any real significance. If comparisons be made, similar to these, embracing many catalogues distributed at various epochs, and including a great number of observations in each group, it seems to me that it might be possible to distinguish between those elements which are progressive with the time and those, if any, which suggest personal equation.

II. Systematic Errors.

Professor Newcomb advances the proposition that, as a practical matter, a normal system of star-places can be adequately represented by two star-catalogues, — especially if these are well separated in epoch. I have no desire to split hairs in a further discussion of this subject. I have only to say that everything depends upon the normal system which is relied upon in the systematic sense for the correction of individual series of observations. If the basis be systematically what it should be, its weight, in that sense, will be very much greater than that of any one of the elements composing it. If it be about equally liable with the separate catalogues to the suspicion of systematic error, it makes little difference whether it be represented by more than two catalogues or not. Professor Newcomb seems to have little confidence in his adopted normal system of star-positions which forms, apparently, an attachment to his computations designed more for ornament than for practical use. Furthermore, if it should turn out that, for the great bulk of what might be termed his secondary standard stars, the proper motions of his normal system depend essentially upon the star-positions of Bradley, then I can understand the reason for the course he adopts.

There is one point in this connection, however, which needs clearing up. Professor Newcomb seems to imply that the reason he employed only Bradley-Auwers proper motions in his investigations, was because he would not have been able to ascertain the systematic corrections for proper motions computed from other sources embracing a shorter interval of time. I freely confess that this proposition appears to me absurd, and therefore I think there must be some misunderstanding, on my part, of what he really means. For example: If we suppose Greenwich

1865 to have a weight of 10, and Bradley 1755 a weight of 1, the weight of centennial motion computed from them would be 1.31. If, now, we imagine a star-catalogue, or combination of catalogues, at the epoch 1835, of the weight 6, and at 1895 of the weight 10, the centennial motions would have the weight 1.35. In every sense the latter would be as precise as the former. It would be as easy to ascertain the systematic error of the latter motions as of the former. It is true that the weight of motions computed from a pair of catalogues might become so small that it would be impossible to distinguish the systematic correction; and this might still be true even if the interval were very great, — as, for instance, between Lacaille's zones for 1751 and Cordoba, or Cape, for 1875. This is, however, a crude way of considering the matter. In deriving proper motion for an important purpose in which motion is the chief object of interest, one would not merely consider the catalogues in pairs, but would follow the course usual in all refined discussions of this kind from the time of Argelander to the present, — namely, he would use at least all the observations best suited for the computation. From the equations forming such a computation can easily be learned how superior in every sense is the weight with which the motion is determined in this manner to that which can be got through the selection of any two catalogues.

III. Relative Value in Precession-Investigation of Right-Ascensions and Declination.

As I consider this to involve the most important point of difference between Professor Newcomb and myself I must examine it in some detail.*

That part of the systematic error in transit which depends upon the brightness of the star, seems to me vastly less to be feared than is the systematic error in the position of the equinox as deduced from the older transit observations of the intensely bright sun. That there may be a very large difference of personal equation in the observation of the limb of the sun, or moon, and of a star by the same observer, is a fact which is generally understood and conceded. Even for the same observer much will depend upon the state of the telescopic image of the sun. Very instructive evidence on this point exists. It will be found in a very clear and definite form in the papers of Wagner and Nyrén on the Pulkowa equinox-determination. (See *VJS.* 1873, p. 46, Wagner; *Das Aequinox für* 1865, Nyrén, p. 27; *Pulk. Obs.* Vol. XII, p. 90, Wagner.) In an elaborate memoir in which every refinement of modern computation is practiced Nyrén derives $+0^{s}.036$ as the correction of Newcomb's equinox, N_1, for 1865, from eleven years' observation at Pulkowa; while Wagner, modifying his calculations to take into account the character of the telescopic images, with the same elaborate care, finds from the same observations this correction to be only $+0^{s}.002$.

Now, the telescopic images, at least down to the third decade of the present century, must have been continually what we would now term bad, if not intolerable. For instance, the object-glass of Bradley's transit was not achromatic, and the effective aperture employed was only one and one-half inches. Only one (coarse) transit wire was usually observed, and thus it requires no vivid imagination to call up apprehensions even more grave and forbidding than those which Professor Newcomb has entertained in regard to the older observations of faint stars.

This is not, however, the whole story by any means. There is the difficulty of determining the obliquity of the ecliptic and the sun's absolute declination. The ability to accomplish these undertakings is of course of fundamental importance in observations to determine the position of the equinox. I think I am entirely within the truth in saying that no one having the requisite knowledge would give the zenith-distance observations of Piazzi any weight whatever, as absolute determinations of the declinations of fixed stars. The same conclusion applies equally to the zenith-distance observations of Maskelyne, which have been accepted, and then grudgingly, only when treated as rigidly differential work. I do not know of a single instance wherein the zenith-distance observations of Maskelyne have been employed in determining the declinations of standard stars, even in a secondary way.

In the next place, Bradley observed with his transit fully exposed to the sun's rays; and there was not much improvement in this respect until long after his time. (Maskelyne protected the pivots by means of mahogany shields.) When one reflects that Bradley's transit weighed only fifty-five pounds, and that it was, at the same time, eight feet long, with an axis four and one-half feet in length, it seems not unreasonable to suppose that his transit-observations may have been subject to systematic errors which would be considered rather large in connection with an instrument of modern construction.

On the general subject of equinox-determinations, in his work upon the *Equatorial Fundamental Stars*, Professor Newcomb says (pp. 22–23): "It is well known that the best determinations of the equinox exhibit discordances far larger than can result from purely accidental errors of observation, and so indicate the existence of systematic errors in the observations of the sun, the nature and causes of which are obscure. * * * * It is well known that the personal equation of an observer is frequently different for the sun and for a star."

What is Professor Newcomb's course under these circumstances? Does he say that, because there is now no means of determining what these systematic corrections of the older observers were, he will reject their sun-observations altogether, as now he proposes to reject the observations of faint stars? Quite the contrary; "Under these circumstances," he says, "the most we can do is to base our determination on the widest range of material at our disposal, depending for accuracy on the number and variety of the determinations employed rather than upon the precision of any one." In this instance he appears to have put aside in the most peremptory manner whatever apprehensions he may have felt. Thus we find the weight which he assigns to BRADLEY's determination of the equinox to be 3 on a scale which assigns the weight 3 to Greenwich 1857 and 1864, each embracing the observations of seven years (p. 33, *Equat. Fund. Stars*). Even the very crude determination by MASKELYNE, covering only two years, has the weight 1; while weight 2 is assigned to PIAZZI's determination, "of which," says Professor NEWCOMB, "I know nothing" (p. 24, *Equat. Fund. Stars*), — a weight exactly equal to that which is assigned to each of the Berlin, Edinburgh and Cambridge series. It is interesting to note, however, that, some years later, when Professor NEWCOMB comes to treat the right-ascensions of the sun, he rejects PIAZZI's work altogether, saying: "It will be seen that PIAZZI's results are thrown out entirely. The wide range of his values of e led to the inquiry whether more consistent results would be obtained by taking shorter periods, but it was found that the values of e varied from time to time in such an irregular way that his instrument must have been affected by some extraordinary source of error, unless some mistake has been made in interpreting or treating the observations", (NEWCOMB's "*Astronomical Constants,*" p. 21).

From what has been said the entire rejection of the equinox-determination from BRADLEY's, PIAZZI's, and MASKELYNE's observations may, therefore, appear to be not an unreasonable procedure. If this course be followed as to Professor NEWCOMB's equations at p. 33, of the *Equatorial Fundamental Stars*, we shall have as the correction of his equinox, N_1,

$$\Delta N_1 = -0^{s}.026 \left(\frac{T-1855}{100}\right)$$

It may be thought that the BRADLEY–AUWERS determination, computed with all the rigor of modern methods in the hands of a master, is entitled to appreciable weight. If this be included with weight 1, we shall have

$$\Delta N_1 = -0^{s}.051 \left(\frac{T-1853}{100}\right)$$

I strongly doubt whether the BRADLEY–AUWERS determination is entitled to a weight so great as this; but to restore Professor NEWCOMB's weight would be to increase the negative correction to a point where it would be in substantial conformity with the result computed by Dr. HILL (*A.J.* 428).

Without attempting a comprehensive examination of the evidence as to the position of the equinox, it may be interesting to notice some of that which is derived wholly from observations of a date later than any included in Professor NEWCOMB's equations. Separating the Greenwich determinations into three equal groups the following table exhibits the corrections, ΔE, to the equinox N_1 derived from the respective sources.

RECENT VALUES OF ΔE APPLICABLE TO N_1.

Observatory	Date	Years of Obs.	ΔE
Greenwich	1875	8	$-0^{s}.020$
Washington	1880	9	-0.015
Greenwich	1883	8	-0.029
Oxford	1888	8	-0.018
Greenwich	1890	8	$+0.015$
Means	1882		-0.013

All the testimony here presented is very consistent with the correction

$$\Delta N_1 = -0^{s}.04 \left(\frac{T-1854}{100}\right)$$

which would be about that which would result from assigning to the AUWERS-BRADLEY determination weight, 0.5. The Pulkowa equinox for 1865 would correct this by $+0^{s}.006$, and the above mean of modern determinations would correct it by $-0^{s}.002$.

I lay no especial stress upon this result, for I think the matter requires a searching revision throughout; and there is much additional evidence which would probably well repay the labor of adapting it for use. At the same time, to astronomers conversant with the subject, I submit these three questions.

First, is the rejection of the equinox-determinations of PIAZZI and MASKELYNE justified by the facts?

Secondly, if, contrary to what I should anticipate, the answer to this first question should be in the negative, then, I ask, what degree of confidence can be attached to any determination of the motion of the equinox by observations of the sun, when, upon a question of modifying the weights of three out of twenty-six determinations (and these three undoubtedly the weakest), our judgement as to what is the true centennial motion of the equinox may vary by nearly 1″.0?

Thirdly, in view of all the evidence from observations of the sun is it reasonable to suppose that the motion of the equinox, N_1, requires a correction having the positive sign?

Leaving aside the question, what correction is required for the motion of the equinox, N_1, we may determine from Professor Newcomb's equations (p. 33, *Eq. Fund. Stars*), the nominal probable error of that motion. This is $\pm 0''.27$. This is equivalent to a probable error of $\pm 0''.30$ in the centennial value of the luni-solar precession, ψ. I think that no one would have the hardihood to contend that this is an exaggeration of this probable error. In fact, when we observe with how great apparent nonchalance Professor Newcomb contemplates the advisability of this or that modification of the motion of the equinox by quantities varying from $+0''.3$ to $+1''.0$, and when we find that Dr. Hill, in a computation entitled to respect, derives a correction which is nearly $-1''.0$, it ought not to be matter of surprise if the probable error of Newcomb's adopted motion of the equinox should be set even higher than $\pm 0''.27$. Professor Newcomb thinks the probable error of ψ from right-ascensions "might be placed anywhere between $\pm 0''.20$ and $\pm 0''.40$" (*The Prec. Const.*, p. 70).

There appear to be two ways in which to seek for a diminution of this uncertainty. First, we may try to bring more and better evidence to bear upon the question as to what is the motion of the equinox indicated by observations of the sun. Especially should observations be made in latitudes more favorable than those of Greenwich and Pulkowa. Secondly, we may devote more careful attention to existing and future observation of star-declinations, in order to see what testimony they offer as to the true amount of precessional motion, and, indirectly, as to the motion of the equinox itself.

The Bearing of Observed Star-Declinations upon the Value of ψ. Referring to our sources of information as to the precession, Professor Newcomb says: "In case of the value derived from the declinations there are fewer sources of uncertainty" (*The Prec. Const.* p. 70). I think he is right in this opinion. The most serious source of uncertainty lies in the liability of the various series of declinations to be affected with an error of the form, $\kappa \cos \alpha$, which Professor Newcomb insists may be very material, even in the best constructed normal system. Yet I find that in its effect upon centennial n, in his computations, he estimates the probable error introduced from this source to be only $\pm 0^{s}.10$ (*A.J.* 426, p. 138, col. 2). My own direct evaluation of this probable error fully confirms this low estimate of Professor Newcomb's. I agree with him that in any problem like this of precessional motion we need to be on guard against sources of systematic error. We may increase the material to be employed in such a way as to reduce the casual error to a merely nominal quantity, so that the probable error of our final result shall not be very much greater than that due to the underlying systematic error. Let us then suppose that the probable error in determining n may be, ideally, brought down to $\pm 0''.10$; we shall then have for the probable error of ψ,

$$\text{p.e. of } \psi = \frac{\pm 0''.10}{\sin \epsilon} = \pm 0''.25$$

This is actually smaller than the corresponding quantity, $\pm 0''.30$, due to uncertainty in our knowledge of the motion of the equinox. But after estimating the probable systematic error of the centennial value of n as $\pm 0''.10$, Professor Newcomb adds that this error may be as great as $\pm 0''.20$. I do not know whether he means by this that $\pm 0''.20$ is to be taken as a sort of upper limit of the error. If the actual probable error be $\pm 0''.10$, then, indeed, may the real error be as much as $\pm 0''.20$ once in 5 trials, and even as much as $\pm 0''.30$ once in 23 trials. Saying nothing of accidental errors, in the same way, the actual error of ψ determined through right-ascensions alone may be as much as $\pm 0''.60$ once in 5 trials, and $\pm 0''.90$ once in about 23 trials. But if he means that the probable error of any well-constructed normal system of declinations at the present time may be as great as $\pm 0''.20$, in its effect upon the determination of n, then I cannot agree with him for reasons which I shall now produce in a form as brief as I can manage.

As the normal system through which to derive the systematic errors of various series of observed star-declinations I shall take my "Catalogue of 500 Stars," published nearly twenty years ago. I choose this, not by any means because it is the best which can be devised, but because it is ready for use, and because various independent tests of its accuracy by Backlund, Newcomb, Chandler and others, together with a great variety of unpublished tests of my own, have shown that it represents fairly well the combined testimony of all the observations of declination which have been made during the present century. For many cogent reasons, which need not be recounted in the present limits of space, this normal system is probably very nearly free from systematic error of the form, $\kappa \cos \alpha$. Rather contrary to what might have been suspected beforehand this form of error in the best series of declinations is not a very serious one. This is well illustrated in the following table, which contains for the best series of declinations in existence 20 years ago the comparison found by subtracting the declinations in each of them from the corresponding declinations of the Normal System, and then collecting the differences in groups of two hours. At the foot of each column in full-faced type is given the coefficient κ, of $\cos \alpha$, derived from the observed numbers for the respective catalogues; and below that line are given numbers indicating the weight which each catalogue received in the formation of the Normal System.

Derivation of $\kappa \cos \alpha$.

R.A.	Konigsb. 1821	Dorpat 1824	Abo 1829	Gwch. 12 yr.	Pulk. 1845	Paris 1853	Gwch. 1857	Gwch. 1864	Leiden 1867	Melb. 1868	Wash. 1868	Gwch. 1870
h	″	″	″	″	″	″	″	″	″	″	″	″
1	+0.15	−0.06	−0.16	−0.04	+0.11	−0.05	−0.03	+0.05	−0.01	+0.11	−0.03	−0.03
3	−0.13	+0.06	−0.05	−0.06	−0.11	+0.18	+0.05	−0.01	−0.02	0.00	−0.08	+0.17
5	−0.21	−0.10	−0.02	−0.06	+0.01	+0.02	+0.08	+0.04	−0.03	+0.04	−0.03	+0.02
7	+0.10	+0.30	0.00	+0.06	−0.06	+0.15	+0.15	−0.13	+0.11	−0.03	+0.07	−0.08
9	−0.05	+0.11	+0.34	0.00	−0.06	−0.02	+0.08	−0.02	−0.03	+0.07	+0.06	−0.01
11	+0.26	−0.02	0.00	0.00	−0.02	−0.11	0.00	−0.11	+0.01	−0.03	+0.05	−0.14
13	−0.03	+0.02	+0.08	+0.06	+0.03	−0.11	−0.16	−0.05	−0.05	−0.04	−0.09	−0.08
15	−0.26	+0.10	+0.02	+0.12	−0.04	−0.11	−0.02	−0.03	−0.01	−0.12	0.00	−0.13
17	−0.08	−0.53	+0.06	+0.01	0.00	−0.18	+0.02	+0.09	−0.05	−0.04	+0.04	+0.05
19	−0.17	−0.02	−0.09	−0.03	+0.10	+0.12	−0.05	−0.06	+0.07	−0.03	−0.12	+0.11
21	+0.14	−0.07	+0.07	−0.09	−0.09	+0.15	−0.03	+0.14	+0.03	−0.03	+0.01	0.00
23	+0.08	+0.12	−0.05	−0.12	+0.05	+0.35	+0.10	+0.04	+0.06	−0.16	+0.12	−0.14
κ	**+0.08**	**−0.02**	**−0.09**	**−0.07**	**+0.01**	**+0.14**	**+0.03**	**+0.06**	**+0.02**	**+0.01**	**+0.01**	**+0.05**
Wt.	4	5	5	4	10	3	2	2	8	2	3	2

From this table it appears that the probable error of the unit of weight is ±0″.086. Recurring, now, to the table on p. [72], "Declinations of 500 Stars," which exhibits a list of weights attached to the respective observed declinations forming the basis of the Normal System here in question, I find for the probable error of κ for weight unity to be ±0″.11, somewhat larger than from the catalogues of largest weight. If now we denote by $\Delta\kappa$ the probable systematic progression for a century of the value of κ applicable to the Normal System we shall find for the weight of κ, at the mean date 1847. 71; and for the weight of $\Delta\kappa$, 1.76. These correspond respectively to probable errors of ±0″.013 and ±0″.085 (say ±0″.09). I do not believe that the actual probable error very much exceeds ±0″.09; and this would be the probable error of n derived in strict conformity with this normal system.

It follows now that, if ψ be determined from declination the resulting probable error would be ±0″.23, while the corresponding minimum for this quantity from right-ascensions is ±0″.30. Thus the weight of ψ from declinations, as compared with that from right-ascensions, is as 9 to 5 — nearly twice as great. But, if it be insisted that these computed probable errors do not represent the entire uncertainty (as they very certainly do not) then I must express my firm conviction that the right-ascension element stands in danger of the relatively greater loss as matters stand. In what way a thorough reconstruction of the bases of investigation would operate as to these relative errors, it would be difficult to predict; but for various reasons, it is certain that the observed declinations must always be an important factor in the investigation of the precessional motion.

Discrepancy between Newcomb's *and* L. Struve's n. The foregoing remarks apply to the ideal case, where there is complete elimination of the influence of the unknowns, contained in the determining equations, upon each other; and where the number of stars compared is sufficiently great. I have dwelt on these points in my preceding papers. That some peculiar influence of a systematic nature attaches to one, or both, of the computations of Newcomb and Ludwig Struve as to n seems to be evident. Professor Newcomb has devoted some care to showing that this difference could not have arisen from a systematic difference between the nearly identical proper motions in declination employed by them (*The Prec. Const.* p. 54). One would have expected the two values of n to come out in substantial agreement; yet they differ 0″.68, and ψ from Newcomb's declinations is larger by 1″.7 than from Struve's. It would not be surprising should this difference turn out to frame a strong indictment against the two-catalogue-one-hemisphere method.

It is worthy of remark, perhaps, that if, in Professor Newcomb's summing up (*The Prec. Const.*, p. 69), we put $\Delta E' = -0''.60$ (a value suggested in this article), and if, in the place of Professor Newcomb's determination of n from declinations, we adopt that of L. Struve (20″.0453), we shall have

$$\begin{array}{ll} \delta\psi \text{ from Right-Ascensions} & -0''.29 \\ \delta\psi \text{ from Declinations} & -0.60 \end{array}$$

or −0″.45 in the mean, against the value +0″.82 which Professor Newcomb adopts. This correction results in the values,

$$\begin{aligned} \psi &= 5035''.57 \\ m &= 4605.91 \\ n &= 2004.60 \end{aligned}$$

I do not pretend to vouch for these quantities as against those found by Professor Newcomb, because I do not think that much can be predicated in favor of any values of the precessional motion which do not involve much more extensive probing into the sources of information contained in the meridian observations of the present century, than any which has yet been undertaken; but I do submit the question to astronomers whether these values are not entitled to equal consideration with Newcomb's.

IV. Meridian Observations of Southern Stars.

It is rather interesting to observe the working of Professor Newcomb's fixed idea when he comes to make objection to my proposition in reference to Southern star-catalogues. Instinctively, he selects only two, out of all the series of observations, as most suitable for his purpose; and apparently he thinks of these purely in reference to the right-ascensions (*A.J.* 426, p. 139). But we need those catalogues chiefly on account of their star-declinations, as I shall presently show; though their help in right-ascension is not to be despised. Professor Newcomb says he could not use the Southern observations of the Cape catalogue for 1840 because he could not determine $\Delta\alpha_\delta$ for it. Let us see how relatively important it was for him to know that term of correction accurately.

For the sake of clearness in this and what follows let us examine the formulas of determination, which take into account the solar motion. We shall put

ρ = Distance to a star, or to group of stars, considered.
c = Solar motion in the same units as for ρ.
$M = \frac{c}{\rho}$
$\Delta\psi$ = Required correction to Luni-Solar precession.
ϵ = Obliquity of ecliptic.
A and D = R.A. and Decl., respectively, of solar apex.
$\Delta\alpha$ and $\Delta\delta$ = Computed proper motions, or means of them considered in groups.

We shall then have

$$(\Delta\psi\cos\epsilon)\cos\delta+(\Delta\psi\sin\epsilon)\sin\delta\sin\alpha+(M\cos D\cos A)\sin\alpha \\ -(M\cos D\sin A)\cos\alpha=\Delta\alpha\cos\delta$$

$$(-M\sin D)\cos\delta+(\Delta\psi\sin\epsilon)\cos\alpha+(M\cos D\cos A)\sin\delta\cos\alpha \\ +(M\cos D\sin A)\sin\delta\sin\alpha=\Delta\delta$$

The first term in the first equation is the one which would suffer from the use of a wrong systematic correction of the right-ascensions, of the form $\Delta\alpha_\delta$. But a moment's consideration will show that the zones at different declinations contribute very differently to the determination of $\Delta\psi\cos\epsilon$, or Δm. If we suppose that the stars employed in our determination are distributed in due proportion over the different areas of sky from pole to pole, we shall have approximately the ideal case of complete elimination of each of the coefficients with reference to the others. This applies with special advantage to the relation of the second to the third term in each of the above equations, by which it results that the value of Δn $(=\Delta\psi\sin\epsilon)$ comes out from each independently of any assumption whatever as to the amount and direction of solar motion. It is now possible to see exactly in what way each of the zones, or areas, contributes to the solution of the problem. Taking the hemisphere as the unit of weight we determine the weight contributed for the terms in $\cos\delta$ through the expression $\frac{3}{2}\int_{\delta'}^{\delta''}\cos^3\delta\, d\delta$; for the terms in $\sin\delta$, through the expression $3\int_{\delta'}^{\delta''}\sin^2\delta\cos\delta\, d\delta$; and for the terms not containing a function of δ, through $\int_{\delta'}^{\delta''}\cos\delta\, d\delta$, each in its own unit.

The following table contains the values of these integrals for the zones indicated. They exhibit the relative weights contributed by each zone, as to the coefficient considered.

Relative Weights of Terms.

Zone	In $\cos\delta$	In $\sin\delta$	Without δ
0° to 30°	0.688	0.125	0.500
30 to 45	0.196	0.229	0.207
45 to 60	0.090	0.296	0.159
60 to 90	0.026	0.350	0.134

It now becomes clear that Professor Newcomb's objection as to the ill effect upon $\Delta\psi\cos\epsilon$ arising from indetermination as to $\Delta\alpha_\delta$ is very much weakened. The first column indicates the relative weights for this term. Of the total weight for determination of $\Delta\psi\cos\epsilon$, taking the entire sphere, only one-seventeenth comes from the area south of −45°, and only about one-seventh from the area south of −30°. I shall show, however, that there is no unusual indetermination as to the correction, $\Delta\alpha_\delta$, for Cape 1840, nor for other Southern catalogues of the better class; so that Professor Newcomb's objection simply falls to the ground.

A little attention will show furthermore that, as against any small sacrifice we may incur as to $\Delta\psi\cos\epsilon$, we shall have made an immense gain as to $\Delta\psi\sin\epsilon$ in two ways.

First, it will be possible to obtain a useful value of this quantity from right-ascensions, though its real weight would be very much smaller than that from declinations,— with equal accuracy of the two coordinates one-third, in practice, probably, still less. But this value would be independent both of terms of correction in right-ascension of the form $\Delta\alpha_\delta$, and of terms in declination of the form $\kappa\cos\alpha$. As the outcome of an extensive and thorough investigation, the comparison of this value of $\Delta\psi\sin\epsilon$ with that from declinations would have a high interest.

Secondly, in the equations formed from the declinations $\Delta\psi\sin\epsilon$ $(=\Delta n)$ would come out independently of the solar motion. When the Bradley-stars alone are used in the deduction of this quantity there is no small degree of indetermination. It is in this respect I should anticipate the greatest gain from the extension of a precession-investigation to the entire sphere.

But in carrying out this plan it would not do to select only two series of observations. It would be necessary to utilize all. It is not necessary to go over the list of Southern star-catalogues; but I must suggest that, in my opinion, Professor NEWCOMB errs when he says that the Cape catalogue for 1840 would be the first that is useful for this purpose. This does not do justice to the Madras catalogue for 1835, by TAYLOR. This contains over 3900 stars south of −30°, and it runs beyond −60° with useful places. I think I shall be able to show that these star-positions are better than their ordinary reputation. I shall confidently look for a great improvement in those star-places, consequent upon the new reduction which Dr. DOWNING has now in hand, and which will undoubtedly be available within a very few years, in time to be combined with the reobservation of those stars at the present time, and with a great number of intermediate determinations. The declinations of BRISBANE are, for the time, good; and the Cape positions for 1850 will prove to be a most useful auxiliary, especially if all of them should be reobserved during the next few years.

For some years I have been making active use of Southern star-catalogues, employing a very decided fraction of my time in that way. It is true that I find much to criticise as to the plan and execution of some of those works in earlier times by men who were more interested in other things. Yet I am sure that those works are not only of value in computing the proper motion of stars, but also that it is possible to free those motions from systematic error to an extent quite sufficient to render them of value in the way I have proposed. To say nothing of my current work upon stars interesting for proper motion, I have computed, from a combination of the principal Southern catalogues, the positions for more than 600 stars south of −22°, of which more than 400 are south of −30°. This has given me a hopeful feeling as to those star-catalogues. As a beginning in the work of reobservation I am now engaged in observing all stars brighter than the seventh magnitude (and of as many that are fainter) between the parallels of −22° and −36°. About 18000 observations have been made at this observatory in the interests of this program, now approaching completion. Thus, in this part of the sky, we shall presently have an interval of observation extending more than 60 years later than TAYLOR's epoch.

It thus happens that I am in possession of a little of the kind of evidence necessary in forming a judgement as to the quality and possibilities concerning the meridian observations upon the southern sky. With the exception of LACAILLE's zones and the Paramatta right-ascensions these seem to me to be neither very much better nor very much worse than contemporary observations upon the northern sky. As soon as the pages of this journal can fairly grant admission to such an article I intend to make public some results of my investigations upon the Southern catalogues; and I shall then take occasion to demonstrate all I have ever said in favor of them.

FILAR-MICROMETER OBSERVATIONS OF (16) *PSYCHE*,

MADE WITH THE 6-INCH EQUATORIAL OF THE DETROIT OBSERVATORY, ANN ARBOR, MICH.,

BY SIDNEY D. TOWNLEY.

[Communicated by the Director of the Observatory.]

1897 Ann Arbor M.T.		*	No. Comp.	Planet — *		Planet's Apparent		log Δp	
				Δα	Δδ	α	δ	for α	for δ
	h m s			m s	′ ″	h m s	° ′ ″		
Feb. 18	11 31 47	1	10 , 6	+0 18.44	+ 4 53.8	10 27 44.38	+ 9 54 53.3	*n*9.048	0.676
26	11 37 4	2	8 , 6	−2 22.61	− 2 51.6	10 21 24.87	+10 37 55.2	*n*8.468	0.664
27	11 39 35	4	8 , 6	+0 19.98	− 3 33.7	10 20 37.80	+10 43 13.1	*n*8.187	0.663
Mar. 6	10 54 31	5	12 , 8	+0 27.54	− 4 22.5	10 15 20.39	+11 18 34.9	*n*8.594	0.655
7	10 54 49	5	12 , 6	−0 16.12	+ 0 29.3	10 14 36.73	+11 23 26.7	*n*8.472	0.654
10	11 6 58	6	12 , 6	+0 9.94	−10 15.0	10 12 29.84	+11 37 30.1	8.325	0.651

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	10 27 23.31	+2.63	+ 9 50 11.7	−12.2	*ρ Leonis*; ½ (*B.J.*+*A.E.*) +2 Paris$_2$ 12860]
2	10 23 41.77	+2.71	+10 40 59.2	−12.4	$\frac{10}{65}$ [Pulk. 752+2 Yarn.$_3$ 4455+Glas.$_1$ 2732+ ½ W.$_1$ 375
4	10 20 15.10	+2.72	+10 46 59.0	−12.2	Micrometer-determination from *3
3	10 19 50.85	+2.73	+10 52 6.2	−12.2	¼ [Kam 1747+3 Leipzig A.G.C. 4017]
5	10 14 50.12	+2.73	+11 23 9.2	−11.8	$\frac{1}{9}$ [W$_1$, 208+2 Rüm. 3142+6 Paris$_2$ 12656]
6	10 12 17.17	+2.73	+11 47 56.7	−11.6	$\frac{1}{6}$ [2 Paris$_2$ 12601+2 Yar.$_3$ 4377+Kam1715+Schj.3769]

RELATIVE POSITIONS OF *HYPERION* AND *IAPETUS*, AND OTHER SATELLITES OF *SATURN*,

MADE WITH THE 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY OF THE UNIVERSITY OF VIRGINIA,

By E. O. LOVETT.

In the following measures, the angles given are each the mean of two comparisons; the distances were obtained from measures of double distances. Corrections have been applied for refraction. Eastern mean time is used (75th Meridian).

Rhea–Hyperion.

1894	Eastern Time h m s	p °	Eastern Time h m s	s ″
April 2	13 3 25	99.66	13 8 37	134.94
	13 28 25	99.81	13 13 36	134.31
	. . .	. .	13 17 40	134.42
	. . .	. .	13 21 5	134.16
25	11 17 9	117.60	11 22 27	65.14
	11 34 38	117.82	11 25 16	65.27
May 1	11 13 4	261.92	11 17 54	133.32
	11 26 51	261.36	11 21 47	133.34

Titan–Hyperion.

1894	Eastern Time h m s	p °	Eastern Time h m s	s ″
March 8	12 5 49	94.33	12 20 32	149.20
	12 35 42	94.78	12 28 14	148.79
12	15 46 32	122.35	15 52 28	31.23
	16 0 12	121.79	15 55 1	31.22
	16 17 34	121.61	16 4 6	30.87
	16 37 53	121.89	16 11 40	30.69
13	16 10 51	120.19	16 16 27	27.19
	16 32 37	119.62	16 19 5	27.68
	. . .	. .	16 22 8	27.67
	. . .	. .	16 25 27	26.87
April 8	14 38 46	225.27	14 51 21	126.26
	15 9 58	225.45	14 55 35	125.84
	. . .	. .	15 0 16	125.85
	. . .	. .	15 4 15	125.78
25	13 0 29	132.99	13 10 34	111.00
26	11 55 59	206.44	12 3 4	85.27
	12 20 30	208.06	12 8 4	85.62
May 21	9 27 29	121.45	9 32 23	36.35
	9 41 30	121.22	9 37 3	36.39
24	11 3 46	246.45	11 7 49	83.15
	11 12 13	247.41	11 8 9	83.11
26	10 10 24	262.05	10 15 45	132.94
	10 22 27	261.78	10 17 31	133.13
June 2	9 40 32	73.71	9 44 53	158.81
	9 49 35	73.79	9 46 5	158.95

Dione–Iapetus.

1894	Eastern Time h m s	p °	Eastern Time h m s	s ″
April 27	14 30 35	201.58	14 33 43	113.89
	14 40 53	200.68	14 37 23	113.97
June 2	12 8 9	328.17	12 11 0	184.75
	12 17 35	328.23	12 14 22	184.73
7	11 49 9	21.23	11 52 1	126.40
	11 56 11	21.35	11 54 17	126.26

Rhea–Iapetus.

1894	Eastern Time h m s	p °	Eastern Time h m s	s ″
March 18	15 29 42	359.25	. . .	. .
23	15 58 18	65.21	16 4 6	167.79
	. . .	. .	16 7 30	167.61
April 25	11 41 57	183.43	11 48 48	132.65
	11 56 19	183.63	11 52 39	132.65
26	12 13 45	156.17	13 18 12	122.00
	13 26 4	155.65	13 22 22	121.96
27	14 13 18	156.69	14 16 50	132.35
	14 22 51	157.45	14 19 47	132.22
28	11 33 35	206.87	11 38 49	142.11
	. . .	. .	11 48 5	141.81
29	10 10 18	240.91	10 16 9	220.53
	10 23 29	240.95	10 19 26	220.69
May 1	11 30 25	245.41	11 33 55	149.04
	11 39 46	245.29	11 37 9	148.84
	13 35 14	244.99	13 38 27	147.56
	13 42 43	244.77	13 40 39	147.59
2	12 57 43	249.48	. . .	. .
June 2	8 55 59	340.14	9 0 6	164.08
	9 3 35	340.21	9 0 59	164.12
	12 19 49	342.36	12 23 32	158.00
	12 26 31	342.27	12 24 17	158.11
7	11 13 37	54.13	11 16 11	173.75
	11 21 1	54.19	11 18 19	173.79
	12 18 45	54.30	12 23 34	170.18
	12 29 4	54.32	12 26 27	170.16

Titan–Iapetus.

1894	Eastern Time h m s	p °	Eastern Time h m s	s ″
March 18	15 25 40	41.47	. . .	. .
23	15 55 30	77.31	16 14 22	217.92
	. . .	. .	16 19 5	217.58
April 26	11 20 39	210.00	11 29 44	188.95
	11 41 28	210.42	11 34 27	188.81
27	13 21 41	234.34	13 27 57	242.79
	13 37 58	234.58	13 33 16	242.94
June 2	9 5 44	311.09	9 10 30	271.88
	9 15 13	311.17	9 11 26	271.96
	12 39 16	313.38	12 43 37	260.44
	12 49 15	313.38	12 44 57	260.54
7	10 59 14	65.70	11 2 49	287.89
	11 9 54	66.20	11 6 24	287.88
	12 31 52	66.96	12 36 14	290.40
	12 45 34	66.96	12 41 31	290.55

Hyperion–Iapetus.

1894	Eastern Time h m s	p °	Eastern Time h m s	s ″
April 25	12 42 21	214.94	12 47 31	121.83
	12 55 45	215.37	12 51 44	121.42
May 1	10 45 14	185.88	10 50 4	42.50
	10 56 14	185.12	10 52 58	42.52
	13 21 11	186.87	13 26 1	42.04
	13 32 23	187.30	13 29 0	42.06
2	10 9 56	205.11	10 13 19	46.28
	10 21 39	204.99	10 17 29	46.34
	12 43 38	208.37	12 47 14	47.45
	12 54 14	209.05	12 50 40	47.34
3	11 16 50	233.96	11 23 36	66.47
	. . .	. .	11 26 22	66.41

OBSERVATIONS OF VARIABLE STARS — No. 6.

By WM. E. SPERRA.

5323. *R Bootis.*

A series of eighteen observations of this star between 1897 June 9 and Sept. 4, yield as the date of maximum 1897 July 25.5 at $7^{M}.8$. Both rise and fall were of nearly equal duration, the star at first date was at $9^{M}.7$, and at last, $9^{M}.5$.

5768. *RR Herculis.*

Nineteen observations of this star, between 1897 April 24 and Oct. 23, indicate as the date of maximum 1897 June 14. The rise was rapid, and the fall quite slow. I have no reliable magnitude-estimates of comparison-stars, so none are given of the star.

7085. *RT Cygni.*

I have thirty-one observations of this star between 1897 March 16 and Sept. 10, from which a minimum of $11^{M}.5$ for May 7, and a maximum of $7^{M}.5$ for July 25.5 is indicated. This series is a continuation of that published in *A.J.* 399. At last observation the star had reached $9^{M}.5$.

OBSERVATIONS OF MINOR PLANETS,

MADE AT THE OBSERVATORY OF VASSAR COLLEGE,

By MARY W. WHITNEY AND CAROLINE E. FURNESS.

1897 Greenwich M.T.	*	No. Comp.	Planet — * $\Delta\alpha$	Planet — * $\Delta\delta$	Planet's Apparent α	Planet's Apparent δ	log $p\Delta$ for α	log $p\Delta$ for δ	Obs.
			(43) Ariadne.						
h m s			m s	′ ″	h m s	° ′ ″			
Sept. 28 16 10 8	1	8	+2 8.49	− 0 7.4	1 20 41.60	+14 46 23.8	*n*9.257	0.614	F
29 16 4 41	1	8	+1 10.43	− 5 56.6	1 19 46.55	+14 40 31.7	*n*9.260	0.615	F
Oct. 26 17 51 55	2	8	+0 51.48	− 1 52.2	0 53 25.33	+11 27 39.3	9.429	0.670	F
			(230) Athamantis.						
Oct. 26 18 10 55	3	10	+0 39.85	+ 1 14.5	1 28 53.67	+18 16 51.6	9.397	0.580	F
			(174) Phaedra.						
Oct. 27 16 21 3	4	6	−0 5.13	+ 8 2.1	2 10 19.76	+30 42 22.1	*n*8.598	0.221	F
			(250) Bettina.						
Nov. 17 15 40 2	5	8	−0 48.22	− 5 19.3	3 23 59.31	+29 10 39.8	*n*9.115	0.300	W
18 13 4 16	5	6	−1 42.82	− 5 3.7	3 23 4.72	+29 10 55.4	*n*9.590	0.484	W
23 13 7 19	6	8	+0 57.87	+10 7.7	3 18 2.23	+29 11 24.6	*n*9.540	0.441	W
24 14 16 37	6	8	−0 4.33	+ 9 54.5	3 17 0.05	+29 11 11.5	*n*9.325	0.338	W
			(120) Lachesis.						
Nov. 23 14 40 56	7	8	+0 16.11	− 4 7.3	3 52 20.76	+30 16 4.6	*n*9.386	0.327	W
24 13 8 8	7	9	−0 35.94	− 6 21.3	3 51 28.73	+30 13 50.6	9.595	0.468	W
27 15 17 9	8	4	−4 59.24	− 2 32.2	3 48 38.45	+30 5 59.6	*n*9.105	0.267	W
			(131) Vala.						
Nov. 23 18 39 41	9	8	+2 9.55	− 3 26.8	2 28 51.02	+12 10 50.6	9.553	0.687	F
24 15 1 56	9	9	+1 28.17	− 4 46.8	2 28 9.65	+12 9 30.6	*n*7.947	0.636	F
			(159) Aemilia.						
Nov. 24 17 0 47	10	6	+1 34.28	+ 5 15.3	4 6 17.60	+11 53 48.0	8.512	0.640	F
27 17 35 0	10	8	−0 59.53	+ 0 15.1	4 3 43.84	+11 48 47.7	9.102	0.646	F
29 17 26 35	11	7	+1 46.79	+ 4 35.6	4 2 2.73	+11 46 3.2	9.110	0.647	F
			(34) Circe.						
Nov. 27 18 41 30	12	10	−0 9.72	+ 9 44.6	4 23 39.51	+13 50 7.2	9.340	0.633	W
29 15 3 47	13	8	+1 21.89	+ 0 21.5	4 21 54.93	+13 43 51.3	*n*9.269	0.629	W
30 14 53 30	13	6	+0 25.37	− 2 50.3	4 20 58.42	+13 40 39.5	*n*9.292	0.631	W
			(287) Nephthys.						
Nov. 29 18 2 20	14	7	−0 50.47	+ 8 18.0	5 14 23.83	+ 7 25 58.0	8.762	0.695	W
Dec. 13 14 5 34	15	9	−0 5.23	− 3 21.4	4 59 59.69	+ 7 30 2.7	*n*9.401	0.707	W
15 15 16 32	16	7	−0 40.66	+ 3 27.2	4 57 54.02	+ 7 33 25.2	*n*9.038	0.695	W

Mean Places for 1897.0 of Comparison-Stars.

*	α	Red. to app. place	δ	Red. to app. place	Authority
	h m s	s	° ′ ″	″	
1	1 18 31.69	+4.42	+14 46 3.4	+27.8	Leipzig A.G. Catal. 396
2	0 52 29.32	+4.53	+11 29 1.1	+30.1	Paris 1234
3	1 28 9.11	+1.71	+18 15 7.1	+30.0	Auwers, Berlin A.G. Catal. 456
4	2 10 19.77	+5.12	+30 33 52.4	+27.6	Paris 2808
5	3 24 41.92	+5.61	+29 15 35.9	+23.2	Cambridge, Graham A.G. Catal. 1712
6	3 16 58.75	+5.61	+29 0 52.6	+24.3	" " " " 1671
7	3 51 58.84	+5.82	+30 19 51.5	+20.1	Bonn VI, +30°594
8	3 53 31.81	+5.88	+30 8 11.2	+20.6	Cambridge, Graham A.G. Catal. 1943
9	2 26 36.52	+4.95	+12 13 50.4	+27.0	Paris 3129
10	4 4 38.09	+5.25	+11 48 13.8	+18.9	Leipzig A.G. Catal. 1221
11	4 0 10.65	+5.29	+11 41 8.3	+19.3	Bonn VI, +11°570
12	4 23 43.87	+5.36	+13 40 5.7	+16.9	Glasgow 1, 1081
13	4 20 27.66	+5.38	+13 43 12.6	+17.2	Leipzig A.G. Catal. 1293
14	5 15 9.09	+5.21	+ 7 17 28.6	+11.4	" " " 2132
15	4 59 59.53	+5.39	+ 7 33 12.3	+11.8	" " " 1985
16	4 58 29.28	+5.40	+ 7 29 46.2	+11.8	" " " 1959

No star seen in the position for DM. 30°583 on either 1897 Nov. 27, or 1898 Feb. 28.

SUNSPOT OBSERVATIONS FOR THE MONTHS JULY-DECEMBER, 1897,

MADE AT MONTEAGLE, TENNESSEE, WITH A TWO-INCH INSTRUMENT, AND AT THE LEANDER McCORMICK OBSERVATORY, WITH A FOUR-INCH EQUATORIAL,

By J. ADAIR LYON.

With the exception of the month of August, and part of September, observations have been made upon every day that the state of weather would permit. The July and August observations were made at Monteagle.

1897	Hour Obs.	No. of Gps	No. of Spts	Fac. Gps	Remarks	1897	Hour Obs.	No. of Gps	No. of Spts	Fac. Gps	Remarks	1897	Hour Obs.	No. of Gps	No. of Spts	Fac. Gps	Remarks
July 1	22	2	4	–	Fair	Aug. 3	21	2	6	–	Clear	Nov. 2	0	2	3	2	Clear
2	22	1	2	–	Cloudy	Sept. 14	1	2	3	0	Fair	3	3	2	2	1	Clear
5	22	2	4	–	Fair	15	1	1	1	0	Fair	6	1	1	3	0	Clear
7	0	3	6	–	Hazy	16	0	2	3	2	Clear	18	1	1	1	0	Hazy
7	23	2	4	–	Cloudy	17	3	2	2	1	Cloudy	19	1	0	0	0	Cloudy
8	22	2	3	–	Clear	17	22	3	7	0	Clear	29	3	1	9	1	Clear
9	21	2	3	–	Clear	20	3	4	14	2	Clear	30	0	1	8	1	Clear
11	21	2	4	–	Clear	21	1	4	7	0	Hazy	Dec. 1	2	2	13	2	Clear
12	21	2	2	–	Clear	24	3	2	10	0	Poor	10	2	2	26	0	Clear
13	21	3	3	–	Clear	25	0	2	19	2	Clear	10	23	2	23	1	Hazy
19	21	2	4	–	Clear	27	0	3	7	1	Clear	15	1	2	15	0	Windy
21	21	2	7	–	Clear	28	0	3	5	3	Clear	17	0	2	9	0	Cloudy
22	21	2	6	–	Clear	Oct. 8	2	1	1	2	Fair	18	2	2	9	1	Cloudy
23	21	2	4	–	Clear	9	1	0	0	3	Fair	23	1	1	1	1	Windy
25	21	2	5	–	Hazy	12	3	1	1	0	Clear	24	1	1	1	1	Clear
26	21	2	3	–	Hazy	13	2	1	1	0	Clear	25	1	0	0	2	Unsteady
27	21	2	5	–	Clear	14	2	1	1	2	Clear	26	3	1	1	1	Hazy
28	20	2	3	–	Clear	15	3	1	3	0	Clear	27	2	2	3	3	Clear
29	21	2	3	–	Clear	16	0	2	9	1	Clear	28	4	1	4	2	Clear
30	21	2	2	–	Fair	18	3	0	0	1	Clear	30	1	3	4	1	Cloudy
Aug. 2	21	2	5	–	Clear	30	0	0	0	1	Clear	31	3	2	2	1	Cloudy

ADDITIONAL CORRECTION TO NEWCOMB'S ABERRATION FROM KÜSTNER'S OBSERVATIONS,

By S. C. CHANDLER.

I ought to have mentioned in the note on p. 165 that Prof. NEWCOMB should have used the symbol ΔA as the correction to 20″.492, not to 20″.445. With this additional correction NEWCOMB's result should be 20″.619, the difference between which and my value 20″.611 is insignificant.

ABRIDGED REFRACTION-FORMULAS FOR PHOTOGRAPHIC PLATES,

By FRANK SCHLESINGER.

In *A.J.* 387 Prof. Jacoby has given formulas which enable us to clear rectangular coordinates X and Y of the effects of refraction; they may be written

$$(1)\quad \begin{aligned} &\text{Correction for } X = Xk\,(1+H^2) + Yk\,(G-\tan\delta)\,H \\ &\text{“ \quad “ \quad } Y = Xk\,(G+\tan\delta)\,H + Yk\,(1+G^2) \end{aligned}$$

where

$$\begin{aligned} G &= \cot(\delta+N) \\ H &= \tan(\theta-\alpha)\,\sin N \operatorname{cosec}(\delta+N) \\ \tan N &= \cos(\theta-\alpha)\,\cot q \end{aligned}$$

The correction for X differs slightly from that first given by Prof. Jacoby, *A.J.* 350. It was first published in essentially the above form by Mr. Dyson, *A.J.* 373.

Other refraction-formulas somewhat simpler in form have been deduced, notably by Prof. Turner in *Mon. Not. R.A.S.*, November, 1893. They may be used whenever the constants of the plate are determined by comparing the measures of some of the stars with their positions as known otherwise, as for example, through meridian observations. It is the object of the present note to show that whenever the constants are so determined the following simple formulas may be employed.

If the rectangular coordinates of a star are to be corrected for an orientation-error r, then we have

$$\begin{aligned} &\text{Correction for } X = -Yr \\ &\text{“ \quad “ \quad } Y = +Xr \end{aligned}$$

r being the sine of the small angle through which the plate is to be rotated. Formulas (1) are therefore equivalent to the following

$$(2)\left\{ \begin{aligned} &\text{Correction for } X = Xk\,(1+H^2) \\ &\text{“ \quad “ \quad } Y = X2k\,GH + Yk\,(1+G^2) \end{aligned} \right.$$

with an orientation-correction,

$$+k\,(\tan\delta - G)\,H$$

If, further, the coordinates are to be corrected for a scale-value error p, we have

$$\begin{aligned} &\text{Correction for } X = +pX \\ &\text{“ \quad “ \quad } Y = +pY \end{aligned}$$

where p is such a quantity that the true scale-value is to be obtained from an approximate one by applying to the latter the factor $(1+p)$; consequently formulas (2) are equivalent to

$$\left. \begin{aligned} &\text{Correction for } X = Xk\,(H^2-G^2) \\ &\text{“ \quad “ \quad } Y = X2k\,GH \end{aligned} \right\}(3)$$

with an orientation-correction as before, and a scale-value correction,

$$+k\,(1+G^2)\,; \quad \text{or,} \quad +k\operatorname{cosec}^2(\delta+N).$$

When the constants of the plate are determined by such a comparison as is mentioned above, then without loss of accuracy we may neglect that part of the refraction which can be regarded as either an orientation or a scale-value correction; for the resulting values of these two corrections, when used with the *abridged* refraction formulas (3), will give correct results. It may happen in rare cases that only the orientation is to be thus determined; formulas (2) are then applicable.

Other formulas might be similarly derived from (1), but formulas (3) will be found to facilitate computation when the measures are arranged in the order of right-ascensions.

It is to be remembered that such abridged formulas save labor only during the process of finding the constants of the plate, and in proportion to the number of comparison-stars used; for these constants having once been determined, the rectangular coordinates of any star are converted into right-ascension and declination by means of corrections which in general contain terms both in X and in Y. If it is desired to know the true orientation and scale-value of a plate, we may either use formulas (1), or else use formulas (3) and apply to these constants the corrections indicated; the latter course is to be preferred when the number of comparison-stars exceeds five or six.

Columbia University, 1898 *February* 26.

CORRIGENDA.

No. 423, p. 119, in equation (2) *for* $\tan\theta$ *put* $\sin\theta$.
“ “ “ “ (4) *insert factor* $\cos\theta$.
No. 429, p. 164, in γ *Equulei*, *for* Küstner *put* Knott.

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DISCOVERIES AND MEASURES OF DOUBLE AND MULTIPLE STARS IN THE SOUTHERN HEMISPHERE,

MADE WITH THE 61-CM. REFRACTOR OF THE LOWELL OBSERVATORY,

BY T. J. J. SEE.

INTRODUCTION.

(I). *Historical Statement.* It is now fifty years since the publication of the results of Sir JOHN HERSCHEL'S survey of the nebulas and double stars of the southern hemisphere executed at the Cape of Good Hope between the years 1834 and 1838; and although the most extensive plans for cataloguing the southern fixed stars have since been carried out by GOULD and THOME at Cordoba, and by Her Majesty's successive astronomers at the Cape, it is not a little remarkable that so considerable a space of time should elapse in an interval of great astronomical activity without a more rigorous survey of the double stars in the richest and most interesting region of the celestial sphere. The labors of HERSCHEL, on several accounts, were devoted principally to the southern nebulas and clusters, the double-star work being regarded as of secondary interest, and allowed to interfere as little as possible with the former inquiry. In stating this result and the circumstances which led to it (*Results of Observations at the Cape of Good Hope*, p. 165) HERSCHEL adds that "to have executed a regular survey of the southern heavens with the twenty-feet reflector, for the purpose of detecting close double stars, would have required at least two additional years, and probably more, since such reviews can only be carried on with effect in those states of the atmosphere when the definition is perfect." Notwithstanding the difficulties here alluded to, in the course of that work he was enabled to detect over 2000 new double stars, a large part of which are sufficiently close and interesting to find place in a modern catalogue. Owing to the inequality in the distribution of our great refractors between the two hemispheres, the obstacles to a double-star survey have continued, though the activity of the Sydney observatory has furnished a connecting link between the time of HERSCHEL and our own age, while the new discoveries made there, and more recently at the Cape by Mr. INNES and by the Harvard Observers at Arequipa, have done much to fill in the otherwise blank state of our knowledge of southern stellar astronomy. GOULD has stated to the writer, in the last letter ever written by that great astronomer, that "Only such double stars are mentioned in the Cordoba volumes as attracted attention when they were observed on the meridian, in the field of the 4.5-inch instrument; and consequently belong to the class which would be called coarse by those who are searching for binaries. The detection of these formed no part of my plan; and in fact they never interested me much, apart from the possible determination of the relative position of the components, as the first step toward the determination of their orbits."

Notwithstanding this modest claim, I find that many important stars were observed at Cordoba, and that the relative positions given by the Cordoba places possess a much higher degree of accuracy than is usual in meridian work under less intelligent and less assiduous direction. In this respect the double-star places deducible from the Cordoba Catalogues have a degree of excellence quite characteristic of all the work done at Cordoba under GOULD'S masterly supervision, of which astronomers have abundant testimony in the well known excellence of the Catalogues themselves.

(II). *The Lowell Survey.* On receiving from Mr. LOWELL an invitation to undertake a survey of the southern heavens for the discovery and measurement of new double stars and nebulas, with the 61-cm. Refractor just finished by the CLARKS, it seemed likely that the principal obstacle encountered by HERSCHEL and later southern observers would be largely overcome, though some hindrance would still be experienced by our location in the northern terrestrial hemisphere. Should Mr. LOWELL carry out his intention of locating the observatory in the southern hemisphere, at some point in Peru, our situation in the future will be more favorable for this work than it has been in the past. As Herschel had given preference to the nebulas, I deemed the double-star work to be far more pressing, and accordingly entered upon the survey of the southern double stars at Flagstaff, 1896 Aug. 1. The Catalogue herewith presented to the public contains discoveries and measures made during the first year and four months of this work.

(III). *Description of Instruments.* Before discussing the results of our labors something ought to be said with regard to the instrumental equipment and the method of observation. The lenses of the great telescope have a clear aperture of 61 cm. (24 inches), and a focal length of 9.45 metres (31 feet). The glass discs from which the lenses were made were cast in Paris by Mantois, and from an optical point of view were pronounced by Mr. Clark the purest and finest of all the large glass discs he ever figured. There is not one *stria* in either lens, nor is there any bubble or other defect larger than a grain of sand; and the color throughout is extremely clear and white. They are figured to the curves usually adopted by Alvan Clark & Sons, and separated in the cell by the space of about 10 cm. The color correction is the most perfect I have seen in any telescope. The images are absolutely round and without a wing or distortion of any kind. And we may add that there is no ghost or other optical illusion which might give trouble in the search for faint companions near bright stars. The new double stars presented in this Catalogue will be the most decisive testimony to the ingenuity and skill employed in making the last* large glass finished by the hand of the late Mr. Alvan G. Clark, to whose memory these discoveries will offer an appropriate tribute when other observers shall be able to recognize what his genius has first made possible to human vision.

The tube of the telescope is of sheet steel, and very heavy* and rigid, so that flexure is almost wholly absent. In proportion to size this has by far the strongest and stiffest mounting ever built for any telescope. The diurnal motion of the telescope is controlled by an electric train with a Bond spring-governor, and the driving clock has performed, with entire satisfaction, the objects remaining practically fixed in the field for an indefinite time. The polar axis is so constructed as to be adjustable to any latitude within 45° of the equator, and hence no difficulty was experienced in the moving from Flagstaff to Mexico. The telescope is provided with two finders with apertures of 10.1 cm. and 6.35 cm. respectively. The micrometer was made by Clark and is of the form usually adopted by that celebrated firm. The turning of the screw has been found to be exceedingly accurate, and the value of one revolution fixed at $R = 6''.680 \pm 0''.004$.

The micrometer has been provided with both an oil and an electric illumination, so arranged that the observer works with bright wires illuminated with red light. The intensity of the illumination can be increased or diminished at will, so that the faintest object can be seen and measured in immediate contact with the wires. The electric illumination was used in all the observations made during 1897; the oil illumination before that date. In all the work the observer kept the line connecting the eyes either parallel or perpendicular to the line joining the stars.

(IV). *Observers.* As a matter of scientific record it ought to be said that neither Mr. Cogshall nor I ever use glasses; and that, so far as we have been able to ascertain by tests, the eyes exhibit no appreciable defects with regard to astigmatic distortion, or as respects the perception of colors. From my previous measures of those stars included in the new work, *Researches on the Evolution of the Stellar Systems*, vol. I, it appears that there are no personal equations which can be established with certainty, but that on the whole the work accords closely with that of Otto Struve, Dembowski and Burnham, whose positions for given stars are generally about a mean of all the positions— the distances being neither too large nor too small. It will be seen that Mr. Cogshall's measures do not differ materially from my own, except in the case of very close objects, where his distances seem to be somewhat larger.

(V). *Discovery of Brilliant Double Stars.* In the course of our sweeps we have discovered companions to a considerable number of bright stars, some of which have already been announced at the time of discovery. For the sake of completeness and to secure uniformity in the numbers assigned to the stars, all of these objects are included in the present Catalogue. The following bright stars are of special interest:—

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* An erroneous statement was recently circulated to the effect that the Yerkes lens is Mr. Clark's last work: that lens was finished in Sept., 1895, and was officially tested on Oct. 17, 18, 19, 1895 (see *Astrophysical Journal*, vol. III, no. 2, p. 154). Mr. Lowell's order for the 61-cm. Refractor was not given till May, 1895, and the first test of the new lens was made by Mr. Lowell and the writer April 15, 1896. The concluding touches were added later, and indeed only a few days before the lens was mounted by Mr. Clark at Flagstaff July 23, 1896. The objective of the Lowell 61-cm. Refractor is therefore the last large lens figured by Mr. Clark, who gave it his usual minute personal attention, and applied the finishing touches with his *own hand*. Nevertheless, we think it proper to say that a very large part of the delicate work of grinding and polishing this superb lens, was done by Mr. Lundin, for many years Mr. Clark's foreman and optician, who has now succeeded him as head of the firm of Alvan Clark & Sons. Mr. Lundin's work shows that he may be expected to maintain worthily the traditions of the illustrious firm, which has contributed so greatly to the progress of astronomical discovery.

* The whole movable part of the instrument weighs about 6000 kilograms, and yet the bearing is so perfect that the observer can move the telescope with one hand without rising from his seat.

Double-Star Number, and desig'n in *U.A.* λ_1 = U.A.	Magnitudes	θ	ρ	Remarks
		°	″	
2 = 11 Ceti	5.7 : 12.3	174.3	2.15	Type of 85 *Pegasi*
6 = α Phoenicis	2.2 : 14.1	280.6	9.04	Very difficult
23 = 79 Eridani	4.7 : 7.3	289.9	0.30	Splendid
26 = 95 Fornacis	6 : 6	180. ±	0.17 ±	Fine
32 = 133 Eridani	5.9 : 13.2	44.0	2.18	Difficult
66 = Canopus	1 : 15	160. ±	30. ±	Very faint comp.
68 = ξ_1 Can. Maj.	4.9 : 14.5	146.6	24.81	
71 = 86 Can. Maj.	6 : 14.7	100.5	10.64	Difficult
76 = 158 Can. Maj	6 : 15	216.4	7.95	Companion obscure
86 = ο Puppis	5.4 : 13.9	198.0	27.69	
87 = 192 Puppis	6 : 14.8	144.5	4.47	Difficult
88 = 60 Carinae	6.5 : 15	185.1	5.76	Most diff., comp. obs
89 = 6 Puppis	5.5 : 13	81.5	11.06	Brilliant system
91 = 223 Puppis	6.9 : 7	302.4	0.39	Fine
92 = *N* Puppis	5.6 : 14	35.8	9.80	Triple
	14.5	87.5	22.86	
96 = 14 Velorum	7 : 7.3	281.0	0.26	Fine system
109 = λ Velorum	2.5 : 14.8	133.7	17.11	Type of *Aldebaran*
111 = κ Velorum	6.2 : 14.5	125.7	11.27	Difficult
113 = 3 Antliae	6 : 14.8	178.1	4.13	Diff., comp. obscure
115 = 150 Velorum	6.5 : 6.5	184.3	0.25	Fine
119 = *p* Velorum	4.6 : 5.2	268.9	0.47	Magnificent
135 = 297 Hydrae	7 : 7	185. ±	0.20 ±	Elegant
140 = 81 Centauri	7.6 : 11	198.5	0.96	Close and unequal
142 = 310 Hydrae	7.6 : 8.8	237.4	0.86	Fine
143 = 89 Centauri	7.2 : 7.4	225.4	0.72	Important
145 = 97 Centauri	7 : 9	49.1	0.70 ±	Fine
151 = x_2 Centauri	7 : 7.2	41.4	0.22	Beautiful
154 = *G* Centauri	4.3 : 13.8	285.5	23.50	
157 = 130 Centauri	6.3 : 13.3	121.3	7.66	Difficult
163 = *p* Centauri	4 : 15	60.3	27.58 ±	Difficult
170 = 183 Centauri	7 : 7	96.3	0.34	Fine
176 = 200 Centauri	7.3 : 13.6	208.6	12.97	
179 = *d* Centauri	5 : 5	104.8	0.19	Magnificent
180 = 228 Centauri	6 : 13.5	230.5	3.90	Nice system
184 = 241 Centauri	7.2 : 12	310.9	0.99	Type of 85 *Pegasi*
186 = 353 Hydrae	8 : 8	196.8	0.20	Excessively close
204 = ψ Centauri	5 : 13.9	86.5	35.16	
207 = η Centauri	2.6 : 14.8	270.1	5.65	Glorious system
218 = 46 Lupi	7 : 7	11.3	0.19	Excessively close
219 = λ Lupi	4.9 : 5.6	178.9	0.30	Splendid
228 = 46 Circini	6 : 14.1	119.6	6.04	Diff. and obscure
229 = q_1 Lupi	4 : 15	239.7	16.74	Triple, type of *Aldebaran*
	14.5	119.3	17.27	
238 = 86 Librae	7.1 : 7.1	137.8	0.20	Triple, South 673
	6	119.1	9.23	
251 = ρ Scorpii	3.2 : 13.7	98.3	38.41	
258 = ι_1 Normae	6.6 : 6.8	266.1	0.84	Triple, fine *h* 4825
	11.1	249.6	10.95	
269 = 45 Normae	6.5 : 6.5	213.4	0.20	Triple, fine
	11	5.0	21.07	
271 = λ Normae	5.2 : 6	152.0	0.35	Elegant
272 = 54 Scorpii	6.6 : 6.6	280.2	0.30	Splendid
273 = 56 Scorpii	7.8 : 7.8	175.5	0.35	Close
284 = 80 Scorpii	6.4 : 7.5	94.4	0.90	Fine
292 = ζ_1 Scorpii	5 : 5.7	185.0	0.23	Splendid
293 = 101 Scorpii	7 : 7	270. ±	0.2 ±	Excessively close
311 = 111 Scorpii	7.5 : 14.9	128.9	3.25	Companion obscure
315 = 114 Scorpii	7.2 : 7.2	203.4	0.31	Very fine
316 = 29 Arae	7.4 : 8.1	178.9	0.59	Elegant
320 = 127 Scorpii	7.7 : 8.3	294.0	0.62	Close
321 = 131 Scorpii	7.5 : 7.8	102.8	0.61	Fine
322 = 135 Scorpii	7.5 : 7.6	1.3	0.20	Excessively close
334 = λ Scorpii	2 : 14.9	109.4	41.73	
335 = θ Scorpii	2 : 14	321.5	6.24	Magnificent
338 *C* = ι_1 Scorpii	3 : 14.1	94.4	38.40	
340 = *G* Scorpii	3 : 14.9	200.6	26.38	Type of *Aldebaran*
	14.7	103.2	41.72	
342 = 179 Scorpii	6.6 : 7.2	284.6	0.42	In a gr. cluster, fine
346 = *W* Sagittarii	1.9 : 14.6	233.4	33.38	Comp. to a variable
350 *C* = δ Sagittarii	3 : 14.5	276.4	25.78	
351 = ε Sagittarii	2 : 14.3	295.1	32.48	
353 = 75 Sagittarii	6 : 6	265. ±	0.18 ±	Fine, close system
360 = 99 Sagittarii	5.6 : 14.7	209.1	12.52	Exceedingly diff.
369 = ο Sagittarii	4.5 : 14.5	236.7	34.53	
389 = 217 Sagitt.	7.4 : 7.5	331.9	0.16	The closest of all
404 = 272 Sagitt.	7.5 : 9.5	65.3	0.49	Close
412 = G.C. 27776	6.3 : 15	210.2	25.86	Blood red
428 = 21 Microsc.	7.5 : 15	187.7	4.41	Companion obscure
431 = 59 Capric.	7.3 : 13.7	341.7	2.63	Difficult
435 = 46 Microsc.	7.2 : 8.2	289.7	0.19	Fine
437 = η Microsc.	4.1 : 14.5	39.6	44.07	
439 = *A* Capricorni	4.9 : 12.2	185.7	26.37	
446 = ζ Capricorni	4 : 14.5	14.0	21.59	Bright star
449 = 102 Capric.	6 : 12.8	197.0	1.82	Type of 85 *Pegasi*
454 = 112 Capric.	6 : 13.5	198.0	5.17	Difficult
473 = ν Gruis	6 : 14.2	114.2	27.83	
478 = Fomalhaut	1 : 14.8	36.2	29.98	Bright star
492 = 19 Sculptor.	6.2 : 8.1	265.1	0.38	Fine system

These objects, in almost every case, present the last extreme of difficulty, and can be seen only with a powerful telescope in a good atmosphere. (See the writer's papers on Atmosphere, Definition of Telescopes, etc., in *A.N.*, nos. 3438, 3449, 3455.) Though I have examined many objects pronounced very difficult by BURNHAM and other modern observers who have used powerful telescopes, I know of no stars more difficult than 11 *Ceti*, *α Phoenicis*, 79 *Eridani*, 158 *Canis Majoris*, 60 *Carinae*, *λ Velorum*, 3 *Antliae*, 241 *Centauri*, *η Centauri*, 46 *Circini*, 111 *Scorpii*, *θ Scorpii*, 217 *Sagittarii*, λ_1 412, 21 *Microscopii*, and 102 *Capricorni*. Indeed, I believe some of these new stars to be the most difficult objects which have ever been discovered; their investigation hereafter will require exceptionally favorable conditions.

While the above pairs are striking for their brilliancy and in this regard rank among the most important of known stellar systems, there is another class of systems which will be found quite numerous in this Catalogue; namely, those stars which are quite close, some being also conspicuous naked-eye stars. As respects distances the stars of the Catalogue are found to be distributed as follows: —

		″		″			
1.	Below	0.25			31	Below 1″.00,	122
2.	Between	0.25	and	0.50,	15		
3.	Between	0.50	and	1.00,	16		
4.	Between	1.00	and	2.00,	40		
5.	Between	2.00	and	5.00,	86		
6.	Between	5.00	and	10.00,	94		
7.	Between	10.00	and	25.00,	129		
8.	Bright stars separated by more than			25.00,	29		

Such of these systems as are below 0″.5 will deserve annual attention from observers having telescopes sufficiently powerful to divide them, but at present this power is possessed by not more than two telescopes in the southern hemisphere. Some of these objects which are below 0″.3 will be irresolvable in all other existing telescopes, and on that account I hope to examine them from time to time in the course of our survey. The 61-cm. refractor ought theoretically to divide equal stars separated by 0″.19, and we have found by experience that, under the best atmospheric conditions, this theoretical limit is realized to perfection, the telescope having on several occasions clearly divided stars separated by only 0″.20. In the case of closer objects, when the division was not complete, the elongation and parallel fringes were so plain as to leave no doubt whatever as to the reality of the phenomena. We have elsewhere emphasized the importance of a steady atmosphere; it will be sufficient in this place to remark that, so far as we have been able to ascertain by numerous comparisons, the seeing at Flagstaff is not surpassed if indeed it is equalled, in the northern terrestrial hemisphere. If we add, to the excellent atmospheric conditions here alluded to, the superb performance of the great telescope, the difficult objects presented in this Catalogue will occasion no surprise; for this instrument and this transparent and steady atmosphere we do not consider an object difficult unless it is below 0″.3 or is fainter than the 14th magnitude for fairly wide objects.

(VI). *Close Double Stars.* Much has been said of late years of the importance of close double stars as compared with wider and easier objects. We may add that, in case the star is not so close that its orbit can never be accurately determined, the claims which have been made are just; but if the object can never be seen except in the greatest telescopes — and even then the measured distances are uncertain by half the whole amount — the motion will after all be very imperfectly known; and the orbits of wider stars where the percentage of error is less will be more exact and possess a higher interest, even if the time required for a revolution is longer. For it must be borne in mind that the eccentricity is the element of highest interest, not the period as many have heretofore assumed. And unless the distance is really measurable, the eccentricity, the inclination, the node, and in fact all the elements, are highly uncertain. And, since great accuracy is ultimately desirable, it is apparent that mere periods of revolution are not sufficient; to make real progress in stellar astronomy we must have other data which will throw light upon the forces and causes at work in these remote regions of space and thus give the science a physical basis.

(VII). *Scope of Stellar Astronomy.* It is but natural that different minds should take different views of the purposes of scientific research. To some who regard chiefly the demands of this generation, it will appear that only such stars should be investigated as are likely to revolve rapidly, while to others who look upon science in the light of history, as the cumulative work of successive ages, it will appear proper to measure all objects likely to be of interest either now, or within the next thousand years. In view of our still very limited knowledge of the sidereal heavens, I am not unwilling to avow my belief in the importance of preserving a wide limit to our catalogues. The course of time is likely to bring to light, as has indeed already happened, systems which are interesting because of their very rapid motion, and others which are philosophically important because of their slow motion and the circumstances from which this arises. To exclude from our catalogues and our attention all but one class of objects — viz. those found to revolve within a few years — would be in the highest degree unphilosophical. For example, if an astronomer were now to observe for the first time the brilliant and coarse-looking *α Centauri*, he could hardly suppose it to be a real double star; and if rough measures were repeated ten years later, there would be little evidence of revolution (because the companion is now in apastron, and moving slowly). In like manner the faint and obscure binary μ^1 *Herculis* would never be picked out from its appearance as an interesting system; yet the fact that such an unpromising object is revolving in a period of only forty-five years, and separated most of the time by one second of arc, shows that peculiar and remarkable systems may be assumed to exist in the heavens. On the other hand, some close objects as Σ115, Σ1165, Σ1867, Σ2215; *h* 3900, *h* 4144, *h* 4409, *h* 4715; *Hare.* 152; *O*Σ171, *O*Σ392, *O*Σ435, *O*Σ482; β679, β619, β628; *A.G.C.* 10, etc., show no more relative motion than do wide objects like the companion of *Aldebaran;* and there would be as much ground for rejecting one class of these systems as the other. In our present limited knowledge of the true phenomena of nature, it seems best that all systems should be measured which give promise of binary character or even physical connection, such as is implied in common proper motion. Accordingly, while I have given particular attention to bright close systems, I have not thought it proper, in view of these considerations, to neglect faint distant companions to bright stars, or faint close systems of even the 10th or 11th magnitude. Since the stellar systems within 75° of the south pole — a portion of the celestial sphere representing three-eighths of the visible universe — have never been systematically measured like those in the northern heavens, the propriety of such a regular survey *de novo* is the more apparent and the need the more urgent. Some of the new stars given in this Catalogue are likely to have extremely rapid motion, and it is not improbable that the observations of a dozen years will furnish material for the approximate definition of their orbits. It is certain that they will possess a high interest at some time in the future; and hence I have been solicitous to measure every object found to be double on at least one night, so that the position now assigned to the companion might then be relied upon with confidence. For it is much more important to measure double stars than merely to discover them; and an excuse can be had for finding and reporting that certain stars are double, without measuring them, provided only that the observer is unable to secure measures of the systems he discovers. In this connection I have no hesitation in indorsing unreservedly the remarks of the late Dr. Gould:— "That a star is or is not double is no more interesting to me than that a mule has a white spot on his right or left fore leg. Yet there are people who spend all their energies in finding out whether a star is or is not double; just as there are others whose ambition is directed to determining whether a star is or is not variable — without the observation in either case, of facts which can be made the basis of scientific investigation. Such so-called discoveries remind me of the boasts of some college professors, as to the power and excellence of the telescopes and apparatus which they never use." (Letter above cited.)

Nevertheless, I think it proper to add that the discovery of systems is important provided it leads to their measurement by other astronomers with better equipment. But unless such discoveries shall lead to measurement, they can have little claim to the notice of men of science. The importance of the discovery of a star has sometimes been over-rated in comparison with its measurement. In this connection we beg to add that *not one of the stars given in the present Catalogue or in the Catalogue of known stars which have been measured* has been observed because of the work of previous observers; every object of whatever description has been swept up by us in the course of our regular search for new systems and in the measurement of those already known. When our results were accumulated and reduced it was found that certain stars had been previously noted by other southern observers, and that others were new. The most difficult objects were of course almost invariably our own discoveries.

(viii). *Region Swept Over.* The region of the heavens swept over in the course of the work embodied in this Catalogue includes the entire zone between −20° and −15° (though some parts have not yet been studied with extreme thoroughness). The more southern region, swept over in Mexico, lies between −45° and −65°, and the hours of right-ascension 4 and 16. It may be stated that probably no stars brighter than the eighth magnitude have been overlooked, and all bright stars have been repeatedly examined. While it was and is our purpose to include a systematic examination of objects brighter than the 10th magnitude, heretofore only an inconsiderable number of systems near the limit of brightness have been discovered and measured. *In the course of this work it is certain that we have examined carefully not less than one hundred thousand stars, and many of them doubtless on several occasions.* It was my original intention to measure each of the systems discovered on three separate nights; but as this method of work was not found to be practicable, I finally settled upon the plan of measuring each system twice on the same night and not recurring to it (except in cases of special interest) unless the star was again picked up as a new object. The two observations secured on the same night are made in a manner as independent as possible, yet they may not be strictly comparable to measures made on separate nights. After our survey of a definite region has been completed, so that a working catalogue can be formed, we hope to secure additional measures of those objects deserving special attention.

(ix). *Arrangement of Catalogue.* The work now presented is arranged in two parts:

i. The Catalogue of New Stars.

ii. The Catalogue of Stars Recognized by Previous Observers, which has been communicated to the *Astronomische Nachrichten.*

With a view of enabling us to recognize the new stars from the whole of the systems measured, we have formed a manuscript catalogue of every known double star within 75° of the south pole. The stars included in this general Catalogue represent the work of Herschel at the Cape of Good Hope, and the lists of wide objects previously published by Dunlop and Rümker, and included in the Catalogue of Brisbane; the double stars discovered at Sydney, the stars discovered or measured by Jacob and Powell in India, by Stone, Burnham, and other American observers; those objects noted as double by the meridian observers in Australia, at the Cape, Santiago, and by Gould at Cordoba; and the more recent discoveries of Sellors, Innes and the Harvard observers (at Arequipa). I acknowledge my personal obligations to Professor E. C. Pickering for a transcript of the unpublished work of the Harvard observers in Peru; to Mr. Russell, Mr. Sellors, Dr. Gill and Mr.

Innes, for complete data of their published and unpublished observations.

It is important that a catalogue of double stars should be numbered continuously in order of right-ascension and that a uniform designation should be employed throughout. As Mr. Coggshall has taken part in the observations and has added a considerable number of stars to the list, and we both desire from reasons of simplicity to include all our stars in one catalogue, we adopt the symbol λ to denote "Stars discovered at the Lowell Observatory." Those discovered by him are indicated in each case by the initial C.; the rest have been discovered by me. As our plan contemplates the publication of subsequent catalogues, we affix to the letter λ in the first catalogue the subscript 1, in order that if it should ultimately be found desirable to arrange all the stars in one catalogue in order of right-ascension it would be possible to do this under the simple symbol λ. We have referred all the star-places to the equator and mean equinox of 1900.0. So far as possible the Cordoba Catalogues have been made the basis of all our positions, and the precessions have been computed rigorously from the excellent and convenient tables given by Gould in the Zone-Catalogues. The places of those stars which occur in the Cordoba or other catalogues are therefore rigorously exact; and such stars as do not occur in the catalogues have been referred wherever possible to catalogue-stars, but in a few cases only approximate places are given. It is my purpose to determine these places rigorously on some future occasion. In this connection we take occasion to remark on the desirability of double-star catalogues being referred to a common epoch, to avoid confusion in the order of the numbers of the catalogue. Defects of the kind indicated exist in numerous published catalogues of double stars and are the occasion of no small perplexity in dealing with the works of several observers. There is no reason why the places of double stars should be more carelessly assigned than the places of single stars in the ordinary star-catalogues, and there will be little excuse for a continuation of the inaccurate work which has heretofore tarnished the luster of this branch of astronomy.

(x). *Centers of Gravity of Stellar Systems.* In connection with these remarks on the places of the fixed stars, it is not inappropriate to point out the desirability of determining the position of one or both of the components of a stellar system with respect to some neighboring star, in order that, when the orbital motion of the system shall develop, these determinations may furnish material for the investigation of the center of gravity by more accurate methods than heretofore have been in use (*Researches on the Evolution of the Stellar Systems*, vol. I, p. 253). Such determinations of the relative masses in stellar systems will eventually become one of the most important problems of stellar astronomy, and measures made at an early date will then possess the highest value. We present in this Catalogue some measures of the kind here indicated. This subject will receive more careful attention in the subsequent progress of the survey, and I trust that it will also be undertaken by some observer in the northern hemisphere. The necessity of this work is especially pressing in the case of stars known to be in orbital motion.

(xi). *Colors of the Stars.* Wm. Struve, in his great systematic survey which forms the basis of stellar astronomy in the northern hemisphere, carefully noted the colors of the components in every system; yet in spite of this philosophic initiative, by a strange and almost unaccountable retrogradation, these interesting phenomena have since been largely neglected by other observers. The desirability of careful records of the colors of southern double stars, of which few now exist, is not to be doubted; and accordingly I have from the beginning recorded in every observation the colors of the components. Considering the very excellent performance of the great telescope and the considerable attention which I have given to this subject, it seems reasonable to assume that our records will be subject to no appreciable bias. In these observations it is not desirable that recourse should be had to fanciful names, which have discredited the work of some previous observers, but that the observer should note carefully the dominant tints of the stars in language which is easily understood by subsequent observers. After some deliberation I have adopted the following terminology as best describing the tints of the spectrum:

1. Red
2. Reddish
3. Orange red
4. Orange
5. Orange yellow
6. Yellow
7. Yellowish
8. White
9. Greenish yellow
10. Bluish yellow
11. Blue
12. Bluish purple
13. Purple
14. Ultra violet or dingy

The colors which most frequently occur in the principal stars are yellow, orange and reddish; in the case of the companion, bluish yellow, blue, bluish purple or purple. Between orange and yellow the gradation in different cases will be very gradual. On the other hand there is no sharp division between bluish and bluish yellow, or between bluish purple and purple, yet the names appear to be sufficiently definite to enable a subsequent observer to detect any important change that might take place.

(xii). *Magnitudes.* The magnitudes assigned to the components in the course of this work are the result of estimates made with each observation. I have assumed that the great telescope under the best atmospheric conditions would show with fair distinctness a star of the 15th magnitude, and therefore the magnitudes adduced upon this basis will probably be found in accord with the standard now generally adopted by astronomers. The extreme dryness of the air at Flagstaff and at Mexico combined with the great elevation of these stations above the sea (2210 and 2320 metres respectively) yields a great advantage in observing stars near the horizon; and accordingly in most of our observations the images were satisfactory and the colors were recognized with certainty. The atmospheric spectra of objects within ten degrees of the horizon are relatively inconsiderable, and certainly not more than one-third or one-fourth as conspicuous as the same phenomena would be in moist countries near the level of the sea. On this account the estimates of the colors and magnitudes, as well as the micrometric measures, will possess a degree of accuracy which observers at low altitudes would hardly anticipate.

(XIII). *Observing Stations.* At Flagstaff the site of the Observatory is Mars' Hill, 130 metres above the town and one and one-half kilometres due west; the Hill is covered with pine forest for more than a kilometre in all directions and is entirely uninhabited, and the atmospheric conditions have proved to be most excellent. The approximate geographical coordinates are: —

$\phi = 35° \, 11'$, $\lambda = 7^h \, 26^m \, 30^s$, west from Greenwich

At Mexico the station was in the western part of Tacubaya (a southwestern suburb, 9 kilometres from the city of Mexico); the site was in an open field, 50 metres above the town of Tacubaya, and one kilometre south by east of the Mexican National Observatory. Though the atmospheric conditions there were quite favorable, they did not on the whole seem to be so good as those in the very exceptional climate of Arizona. The work began at Flagstaff Aug. 1, 1896; on Nov. 9, the lenses were removed and the telescope taken down preparatory to shipment to Mexico; the lenses were remounted there Dec. 28, though the weather did not permit observations of value till Jan. 4, 1897. The lenses were again removed March 29 and remounted at Flagstaff May 14.

(XIV). *Cause of Bad Seeing.* The recent investigations of Mr. Douglass and the writer on atmospheric currents (*A.N.* 3455), have at last disclosed the cause of bad seeing, or the deterioration of the images of a star when the sky is clear and the telescope itself is practically perfect. This singular cause has been found in the elements of the stream lines which make up the larger atmospheric currents; each of these small elements rarifies or condenses the rays entering the objective of the telescope, and the result is that the lens is illuminated in patches of varying intensity. Each portion of the surface of the lens so illuminated will produce a partial image in the focal plane; but as the incident rays are not parallel, the partial images are not perfectly superposed into one composite image. The stream elements being in motion there is necessarily a shifting of the positions of the partial images in the focal plane corresponding to the opposite motion of the current; the rate of motion of the partial images will depend on the velocity of the current, while their prominence will depend on the character of the elements which make up the current. Should the partial images be intense and in very rapid motion, they may produce on the retina the impression of a continuous elongation of the star in the direction of the moving current. This deceptive elongation due to atmospheric causes accounts for the occasional entry of single stars in catalogues of double stars.

As a general rule I have found that the smaller the elements in which the lens is divided, and the more rapid the currents, the worse the blurring; while the larger the elements the greater the bodily motion of the image.

(XV). *Magnifying Power.* Throughout the observations we have uniformly employed a magnifying power of 500, in detecting companions and elongations of stars; but in the case of very close objects, powers of 750, 1000, and 1500 have been used. It is unnecessary to add that hundreds of suspects have been examined and re-examined, and, unless the evidence of duplicity was regarded as conclusive, have been finally rejected. Realizing the essential absence of powerful telescopes in the southern hemisphere, and therefore what time may elapse before other observers will be able to confirm or extend our work, we have been the more solicitous not to include in the Catalogue any object of whose duplicity there remained in our minds the least doubt. Notwithstanding every care, it is not impossible that a very small number of the objects may prove to be deceptions, as has invariably happened with all previous observers of double stars.

(XVI). *Acknowledgements.* My warmest thanks are due to my assistants, Mr. W. A. Cogshall, B.Sc., and Mr. S. L. Boothroyd, B.Sc., who have throughout the work maintained the most unflagging zeal and interest in securing the best results, and who have added no inconsiderable contributions to the sum of our labors. They have assisted in all the observations and reductions and in the work of identification; also in the extensive undertaking of preparing the manuscript catalogue of all double stars within 75° of the south pole. Their work has been done with care and accuracy, and in the case of difficult objects they have always given me the result of their judgement. Mr. Cogshall's discoveries and micrometric work need no commendation.

To Mr. Lowell I desire to express my warmest thanks for every possible courtesy and a constant sympathy and unfailing interest in all our efforts. His firm grasp of astronomical problems and his broad and noble views of science, combined with an enlightened appreciation of our results, have contributed no small part to whatever may be found of value in the present Catalogue.

Lowell Observatory, Mars' Hill, Flagstaff, Arizona, 1898 *Jan.* 1.

FIRST CATALOGUE OF NEW DOUBLE AND MULTIPLE STARS IN THE SOUTHERN HEMISPHERE, DISCOVERED AT THE LOWELL OBSERVATORY.

λ_1 1 *C.*

Cord. Z.C. 23^h1630

$\alpha = 0^h\, 0^m\, 51^s.1$; $\delta = -36^\circ\, 53'\, 3''.3$

8.5, yellow ; 12, bl. yellow

t	θ_o	ρ_o	
	°	″	
1896.799	320.4	1.49	C.
.799	325.7	1.46	See
.851	324.0	5.06	"
.851	323.9	5.03	"
1896.834	324.5	4.85	

λ_1 2 = G 11 *Ceti**.

Cord. G.C. 27.

$\alpha = 0^h\, 2^m\, 40^s.2$: $\delta = -23^\circ\, 3'\, 50''.8$

5.7, yellow : 12.3, purple

1897.736	174.3	2.19
.736	174.3	2.12
1897.736	174.3	2.15

Very difficult system, resembling 99 *Herculis.*

* The constellation numbers and letters of the bright stars in this catalogue are uniformly those of GOULD's *Uranometria Argentina*, and no others are admitted.

λ_1 3.

Cord. G.C. 63

$\alpha = 0^h\, 4^m\, 46^s.1$; $\delta = -34^\circ\, 20'\, 26''.9$

8.2, yellow ; 10, purple

1896.703	191.7	1.03
.731	185.0	1.12
.731	186.7	1.29
1896.722	187.8	1.15

Most interesting system.

λ_1 4.

Cord. DM. 28°98

$\alpha = 0^h\, 16^m\, 36^s.1$; $\delta = -28^\circ\, 47'\, 33''.9$

8.5, yellow ; 12.2, bluish

1896.753	249.1	3.03
.772	248.6	3.23
.772	251.2	3.27
1896.766	249.6	3.18

Important physical system.

λ_1 5.

Cord. Z.C. 0^h517

$\alpha = 0^h\, 20^m\, 42^s.7$; $\delta = -35^\circ\, 22'\, 56''.9$

8.8, yellow ; 12.5, bluish

1896.733	70.8	3.78
.733	73.0	3.95
.775	76.6	3.78
1896.747	73.5	3.84

Delicate system.

λ_1 6 = α *Phoenicis.*

Cord. G.C. 355

$\alpha = 0^h\, 21^m\, 20^s.0$; $\delta = -42^\circ\, 50'\, 47''.4$

2.2, deep orange ; 14.1, purple

t	θ_o	ρ_o
	°	″
1896.7	275. ±	8. ± suspected
1897.028	287.8	9.68(¹)
.030	275.5	9.57
.736	278.6	7.88(²) est. 9″. ±
1897.265	280.6	9.04

(¹) Very difficult, but certainly real: seen for some moments continuously. Former suspicion at Flagstaff confirmed.

(²) Fairly distinct at moments of best seeing. Splendid system of great interest, but very difficult on account of the faintness of the companion. A suitable object for testing steadiness of atmosphere and power of telescopes.

λ_1 7.

Cord. G.C. 394

$\alpha = 0^h\, 23^m\, 42^s.6$; $\delta = -33^\circ\, 19'\, 7''.0$

8.2, yellow ; 12 bluish

1896.703	199.8	9.05
.755	199.7	8.50
.791	201.5	9.14
1896.750	200.3	8.90

λ_1 8.

O.A. 236

$\alpha = 0^h\, 25^m\, 34^s.4$; $\delta = -19^\circ\, 10'\, 22''.0$

7.9, yellow ; 10.8, bl. yellow

1897.753	116.7	6.82
.753	116.4	6.91
1897.753	116.5	6.86

λ_1 9.

Cord. DM. 31°300

$\alpha = 0^h\, 44^m\, 23^s.8$; $\delta = -31^\circ\, 10'\, 5''.8$

8.8, yellow ; 13.7, bluish

1896.753	249.4	3.97
.788	245.1	3.72
.788	244.4	3.94
1896.777	246.3	3.88

Difficult and interesting system.

λ_1 10.

Cord. DM. 22°358

$\alpha = 0^h\, 57^m\, 32^s.3$; $\delta = -22^\circ\, 8'\, 36''.1$

8, yellow ; 10.3, purple

1897.627	322.5	5.02
.627	323.4	4.86
1897.627	323.0	4.94

λ_1 11.

Cord. Z.C. 1^h333

$\alpha = 1^h\, 13^m\, 56^s.6$; $\delta = -27^\circ\, 2'\, 6''.2$

8, yellow ; 8.8, yellow

t	θ_o	ρ_o
	°	″
1896.829	313.1	1.92
.843	316.1	1.89
.843	318.3	1.83
1896.839	315.8	1.88
1897.736	314.4	2.21
.736	313.2	1.91
1897.736	313.8	2.07

λ_1 12.

Cord. G.C. 1242

$\alpha = 1^h\, 14^m\, 42^s.6$; $\delta = -25^\circ\, 28'\, 21''.6$

8, yellow ; 8, yellow

1897.737	205. ±	0.15 ±

Excessively close system; clearly and distinctly elongated, but no trace of separation. Excellent and careful estimates.

λ_1 13.

Cord. G.C. 1285

$\alpha = 1^h\, 16^m\, 59^s.2$; $\delta = -24^\circ\, 39'\, 10''.4$

8, yellow ; 8.5, yellow

1897.627	305.3	0.21 est. 0″.25
.627	306.7	0.27
1897.627	306.0	0.24

Fine close system, not quite separated with power of 750.

λ_1 14 = G 157 *Ceti.*

Cord. G.C. 1421

$\alpha = 1^h\, 24^m\, 48^s.2$; $\delta = -22^\circ\, 8'\, 48''.5$

6, yellow ; 12.8, bluish

1897.753	250.1	22.56
.753	249.2	22.23
1897.753	249.6	22.39

λ_1 15.

Cord. G.C. 1639

$\alpha = 1^h\, 36^m\, 25^s.1$; $\delta = -22^\circ\, 13'\, 30''.2$

8.1, yellow ; 9.7, bl. yellow

1897.736	311.3	2.83
.736	311.0	2.65
1897.736	311.1	2.74

λ_1 16.

Cord. G.C. 2092

$\alpha = 2^{h}\,1^{m}\,20^{s}.3$; $\delta = -22^{\circ}\,37'\,49''.5$

8.1, yellow ; 9.1, bl. yellow

t	θ_0	ρ_0
	°	″
1897.736	37.6	0.47
.736	37.8	0.41
.753	34.4	0.64
.753	34.6	0.65
1897.741	36.1	0.54

Fine, close system of great interest.

λ_1 17.

O.A. 1387

$\alpha = 2^{h}\,7^{m}\,23^{s}.4$; $\delta = -21^{\circ}\,18'\,58''.6$

7.9, yellow ; 10.8, purple

1897.753	358.0	9.04
.753	358.4	9.04
1897.753	358.2	9.04

λ_1 18.

Cord. G.C. 2399

$\alpha = 2^{h}\,16^{m}\,16^{s}.2$; $\delta = -35^{\circ}\,34'\,11''.6$

7.9, yellow ; 8.4, yellow

1897.720	62.6	1.30
.720	61.6	1.27
1897.720	62.1	1.28

λ_1 19.

Cord. G.C. 2837

$\alpha = 2^{h}\,36^{m}\,2^{s}.3$; $\delta = -24^{\circ}\,33'\,54''.9$

8, yellow ; 8.6, yellow

1897.731	324.2	0.61 est. 0″.55
.731	323.4	0.53
1897.731	323.8	0.57

λ_1 20 = τ_2 *Eridani.*

Cord. G.C. 3034

$\alpha = 2^{h}\,46^{m}\,30^{s}.1$; $\delta = -21^{\circ}\,24'\,55''.3$

4, yellow ; 14.9, bluish

1897.753	128.3	51.92

Faint companion to a bright star.

λ_1 21.

O.A. 1861

$\alpha = 2^{h}\,47^{m}\,14^{s}.2$; $\delta = -21^{\circ}\,42'\,6''.8$

7.5, yellow, ; 7.5, yellow

1897.622	98.8	0.35
.622	97.4	0.37
1897.622	98.1	0.36

Very fine system barely separated, near τ_2 *Eridani* = λ_1 20, which is n.p.

λ_1 22.

Cord. DM. 30°1227

$\alpha = 3^{h}\,8^{m}\,26^{s}.1$; $\delta = -30^{\circ}\,25'\,25''.5$

8, yellow ; 9.7, bluish

1897.720	339.0	0.97
.720	338.5	0.94
1897.720	338.7	0.95

A nice system.

λ_1 23 = G 79 *Eridani.*

Cord. G.C. 3588

$\alpha = 3^{h}\,13^{m}\,56^{s}.7$; $\delta = -22^{\circ}\,52'\,36''.0$

4.7, orange yellow ; 7.3, purplish

t	θ_0	ρ_0
	°	″
1897.731	289.1	0.32 est. 0″.3
.731	290.7	0.28
1897.731	289.9	0.30

One of the most interesting of known double stars, and the most difficult object of this class I have ever measured. More difficult than 95 *Ceti*, which has been measured only three times since 1854. Suspected with 500, and distinctly divided with 1500. A superb test for atmosphere and telescope.

λ_1 24.

Cord. G.C. 3746

$\alpha = 3^{h}\,21^{m}\,58^{s}.4$; $\delta = -45^{\circ}\,37'\,14''.3$

7, yellow ; 11, purplish

1897.019	343.6	3.21
.077	339.3	3.04
.077	342.7	3.61
1897.058	341.8	3.29

Fine physical system.

λ_1 25.

Cord. G.C. 3755

$\alpha = 3^{h}\,22^{m}\,33^{s}.7$; $\delta = -28^{\circ}\,54'\,38''.2$

6.5, orange yellow ; 11.8, bl. purple

1897.720	17.7	10.02
.720	17.2	10.22
.750	18.5	9.67 hazy
.750	18.8	10.05
1897.735	18.0	9.94

λ_1 26 = G 95 *Fornacis.*

Cord. G.C. 3873

$\alpha = 3^{h}\,28^{m}\,7^{s}.7$: $\delta = -24^{\circ}\,57'\,20''.8$

6, yellow : 6, yellow

1897.753	180. ±	0.17 ±

One of the closest systems known, excellent and careful estimates.

λ_1 27.

O.A. 2344

$\alpha = 3^{h}\,28^{m}\,25^{s}.7$; $\delta = -19^{\circ}\,35'\,43''.4$

8.2, yellow ; 8.8, yellow

1897.832	351.4	0.36
.832	350.8	0.32 est. 0″.3
1897.832	351.1	0.34

Barely divided.

λ_1 28.

Cord. G.C. 3943

$\alpha = 3^{h}\,31^{m}\,8^{s}.6$; $\delta = -29^{\circ}\,25'\,26''.0$

7.3, orange yellow ; 11.9, purple

1897.720	103.7	10.19
.720	102.7	10.30
1897.720	103.2	10.24

λ_1 29.

Cord. G.C. 4017

$\alpha = 3^{h}\,33^{m}\,54^{s}.3$; $\delta = -50^{\circ}\,17'\,10''.7$

7.3, yellow ; 12.1, bl. purple

t	θ_0	ρ_0
	°	″
1897.030	258.0	10.15
.077	253.5	10.21
.077	258.4	10.21
1897.062	255.0	10.19

λ_1 30.

Cord. G.C. 4176

$\alpha = 3^{h}\,41^{m}\,44^{s}.1$; $\delta = -54^{\circ}\,47'\,42''.8$

A B

7.9, yellow ; 8, yellow

1897.028	291.6	0.50
.088	289.3	0.71
.088	290.1	0.69
1897.068	290.3	0.63

C, 12.5, purplish.

$\frac{A\,B}{2}, C$

1897.088	6.2	5.98
.088	7.4	5.77
1897.088	6.8	5.88

Fine triple.

λ_1 31.

Cord. G.C. 4210

$\alpha = 3^{h}\,43^{m}\,14^{s}.0$; $\delta = -48^{\circ}\,12'\,13''.5$

7.6, yellow ; 12.8, bl. purple

1897.019	76.4	7.10

Companion faint and delicate.

λ_1 32 = G 133 *Eridani.*

Cord. G.C. 4225

$\alpha = 3^{h}\,44^{m}\,2^{s}.9$; $\delta = -36^{\circ}\,24'\,48''.6$

5.9, yellow : 13.2, purple

1897.731	43.4	2.16
.731	44.5	2.20
1897.731	44.0	2.18

An exceedingly unequal pair separated with great difficulty.

λ_1 33.

Cord. DM. 22°1347

$\alpha = 3^{h}\,45^{m}\,36^{s}.9$; $\delta = -22^{\circ}\,15'\,15''.6$

7, yellow ; 10.8, purple

1897.722	298.8	10.62
.722	299.6	10.84
1897.722	299.2	10.73

λ_1 34.

Cord. G.C. 4724

$\alpha = 4^{h}\,9^{m}\,26^{s}.2$; $\delta = -25^{\circ}\,47'\,0''.1$

7.1, yellow ; 12.7, purple

1897.758	37.9	19.57
.758	38.6	20.00
1897.758	38.2	19.78

λ_1 35.

Cord. Z.C. 4^h472
$\alpha = 4^h\,15^m\,27^s.2$; $\delta = -31°\,49'\,5''.4$
8.2, yellow ; 14.3, purple

t	θ_o	ρ_o
	°	″
1897.829	126.1	2.55
.829	126.5	2.28
1897.829	126.1	2.41

Interesting and difficult system.

λ_1 36.

S.D. 19°885
$\alpha = 4^h\,16^m\,25^s.0$; $\delta = -19°\,34'\,22''.4$
6.8, orange ; 13.7, purple

1897.750	346.9	7.81
.750	347.0	8.03
1897.750	347.0	7.92

λ_1 37.

Cord. G.C. 5072
$\alpha = 4^h\,26^m\,49^s.8$; $\delta = -25°\,11'\,41''.8$
7.5, yellow ; 11 purple

1897.760	21.4	11.81
.760	21.0	12.06
1897.760	21.2	11.95

λ_1 38.

Cord. Z.C. 4^h1080
$\alpha = 4^h\,33^m\,9^s.9$; $\delta = -29°\,29'\,48''.5$
7.1, yellow ; 11.3, purple

1897.835	232.2	6.47
.835	233.2	6.59
1897.835	232.7	6.53

λ_1 39.

Anon. near O.A. 3392
$\alpha = 4^h\,43^m\,22^s.7$; $\delta = -20°\,59'\,20''.0$
10.2, bl. yellow ; 11.2, bl. yellow

1897.750	280.1	2.64
.750	279.6	2.60
1897.750	279.8	2.62

λ_1 40.

Cord. G.C. 5490
$\alpha = 4^h\,45^m\,59^s.6$; $\delta = -50°\,3'\,29''.0$
$A\ B$
8.6, yellow ; 8.6, yellow

1897.099	283.7	0.41
.099	285.9	0.46
1897.099	284.8	0.43

Separated at moments. C, 12.8, purplish.

$\frac{A\ B}{2}$, C = Cord. dpl.

1897.019	255.6	[4.78]	
.099	257.5	5.69	
.099	258.3	5.91	
1897.073	257.1	5.80	
Cordoba places give:			
1878.97	259.0	4.71	$3n$.

An important triple.

λ_1 41.

Cord. G.C. 5548
$\alpha = 4^h\,48^m\,46^s.6$; $\delta = -30°\,49'\,33''.0$
7.5, yellow ; 13.9, bl. purple

t	θ_o	ρ_o
	°	″
1897.829	122.5	9.37
.829	122.8	9.33
1897.829	122.7	9.35

Companion faint.

λ_1 42.

Cord. G.C. 5561
$\alpha = 4^h\,49^m\,1^s.9$; $\delta = -51°\,53'\,34''.5$
7.9, yellow ; 7.9, yellow

1897.030	[103.0]	[0.66]
.099	118.0	0.50
.099	116.5	0.46
1897.076	117.2	0.48

Fine close system of equal stars, barely divided.

λ_1 43.

Cord. Z.C. 4^h1900
$\alpha = 4^h\,55^m\,30^s.2$; $\delta = -53°\,32'\,52''.4$
7.5, orange ; 12.5, bluish

1897.025	310.7	8.25

λ_1 44.

Cord. G.C. 5741
$\alpha = 4^h\,57^m\,7^s.2$; $\delta = 23°\,51'\,21''.4$
7.5, yellow ; 9.8, purple

1897.829	333.9	1.87
.829	333.7	1.99
1897.829	333.8	1.93

A nice system.

λ_1 45.

Cord. G.C. 5842
$\alpha = 5^h\,1^m\,55^s.2$; $\delta = -56°\,26'\,30''.2$
7.9, yellow ; 8, yellow

1897.025	102.5	0.38
.109	113.8	0.45
.123	125.9	0.35
1897.086	114.1	0.39

Close and elegant system, at intervals distinctly separated.

λ_1 46.

Cord. DM. 22°2016
$\alpha = 5^h\,3^m\,4^s.2$; $\delta = -22°\,46'\,53''.6$
7.3, or. yellow ; 11.8, purple

1897.758	357.3	13.71
.758	357.1	13.90
.777	358.6	14.36
.777	358.1	14.30
1897.767	357.8	14.07

λ_1 47.

Cord. DM. 22°2039
$\alpha = 5^h\,5^m\,30^s.1$; $\delta = -22°\,36'\,54''.1$
6.5, yellow ; 13.4, purple

t	θ_o	ρ_o
	°	″
1897.758	39.8	3.48
.758	39.9	3.32
.829	38.3	3.62
.829	39.2	3.64
1897.783	39.3	3.52

Interesting and difficult system.

λ_1 48.

Cord. DM. 28°2028
$\alpha = 5^h\,8^m\,51^s.3$; $\delta = -28°\,34'\,37''.2$
8, yellow ; 9.9, purplish

1897.835	2.7	2.27
.835	1.5	2.37
1897.835	2.1	2.32

λ_1 49.

S.D. 18°1046
$\alpha = 5^h\,13^m\,17^s.5$; $\delta = 18°\,14'\,19''.9$
8.1, yellow ; 13.3 bl. purple

1897.772	179.4	5.00
.772	180.3	5.02
1897.772	179.8	5.01

Companion faint.

λ_1 50 = G 31 *Leporis.*

Cord. G.C. 6109
$\alpha = 5^h\,14^m\,23^s.1$; $\delta = -18°\,14'\,12''.2$
5, yellow ; 12.8, bluish

1897.772	199.5	28.81
.772	198.9	29.06
1897.772	199.2	28.93

Faint companion to bright star.

λ_1 51.

Cord. G.C. 6129
$\alpha = 5^h\,15^m\,13^s.8$; $\delta = -41°\,8'\,52''.7$
8, yellow ; 8.5, yellow

1897.044	92. ±	0.7 ±
.071	98.3	0.59
.071	96.2	0.63
1897.062	95.5	0.64

Fine, close system; afterwards independently discovered by INNES.

λ_1 52.

Cord. G.C. 6231
$\alpha = 5^h\,19^m\,26^s.1$; $\delta = -53°\,24'\,37''.1$
8.3, yellow ; 11.5, bluish

1897.019	336.1	7.35
.109	339.9	8.18
.109	339.1	8.20
1897.079	338.5	7.91

λ_1 53.

O.A. 3974

$\alpha = 5^h\,23^m\,20^s.1$; $\delta = -20°\,59'\,52''.4$

8.5, yellow ; 8.5, yellow

t	θ_o	ρ_o
	°	″
1897.758	13.6	0.29
.758	16.4	0.31
1897.758	15.0	0.30

Fine double, not quite separated.

λ_1 54.

Cord. G.C. 6437

$\alpha = 5^h\,28^m\,15^s.9$; $\delta = -27°\,43'\,46''.3$

7.3, yellow ; 12.3, bluish

1897.835	269.8	14.12
.835	269.4	14.08
1897.835	269.6	14.10

λ_1 55.

Cord. Z.C. 5h1577

$\alpha = 5^h\,42^m\,51^s.3$; $\delta = -47°\,25'\,12''.9$

8.4, yellow ; 12, bl. purple

1897.096	308.5	0.78
.096	308.1	0.86
.134	309.8	1.06
1897.109	308.8	0.90

Fine close system of high interest.

λ_1 56.

Cord. Z.C. 5h1736

$\alpha = 5^h\,46^m\,43^s.0$; $\delta = -24°\,22'\,2''.6$

8, yellow ; 11.3, bluish

1897.760	237.3	7.05
.760	237.1	7.26
1897.760	237.2	7.15

λ_1 57.

Cord. G.C. 6988

$\alpha = 5^h\,51^m\,38^s.6$; $\delta = -21°\,42'\,4''.5$

6.2, yellow ; 14.4, bl. yellow

1897.799	107.4	25.11
.799	107.4	25.02
.856	108.0	25.66
.856	107.6	25.79
1897.827	107.6	25.40

Interesting companion to bright star.

λ_1 58.

O.A. 4575

$\alpha = 5^h\,58^m\,36^s.0$; $\delta = -21°\,48'\,16''.6$

7.5, yellow ; 10.8, purple

1897.804	206.1	1.70
.804	206.4	1.74
1897.804	206.2	1.72

Very nice system.

λ_1 59 = G 84 *Leporis.*

Cord. G.C. 7195

$\alpha = 5^h\,59^m\,13^s.7$; $\delta = -26°\,17'\,3''.7$

6, orange ; 15, purplish

t	θ_o	ρ_o
	°	″
1897.835	201.4	21.34
.835	203.8	21.26
1897.835	202.6	21.30

Companion excessively faint. measures of distance precarious.

λ_1 60.

Cord. Z.C. 6h60

$\alpha = 6^h\,2^m\,38^s.9$; $\delta = -32°\,2'\,3''.7$

7, yellow ; 12.3, purple

1897.772	82.8	26.01
.772	83.8	26.21
1897.772	83.3	26.11

λ_1 61 = G 7 *Puppis.*

Cord. G.C. 7384

$\alpha = 6^h\,5^m\,38^s.0$; $\delta = -44°\,20'\,21''.7$

6.5, yellow ; 13.3, purplish

1897.142	121.5	32.30
.142	119.6	32.72
.159	119.1	33.17
1897.148	120.1	32.73

Faint companion to a bright star.

λ_1 62.

Cord. D.M. 22°2825

$\alpha = 6^h\,7^m\,1^s.7$; $\delta = -22°\,48'\,8''.2$

A B

8.1, yellow ; 8.2, yellow

1897.804	97.1	0.63
.804	99.1	0.61
.856	94.4	0.38
.856	95.0	0.34
1897.830	96.4	0.50

System of highest interest, barely divided. *C*, 13.3, bl. yellow.

$\frac{A\,B}{2}, C$

1897.804	324.2	24.88
.856	324.7	24.41
1897.830	324.4	24.64

An important triple.

λ_1 63.

Cord. DM. 22°2837

$\alpha = 6^h\,7^m\,32^s.1$; $\delta = -22°\,46'\,15''.4$

7.5, yellow ; 12.8, bl. yellow

1897.804	166.4	17.53
.804	165.7	17.41
1897.804	166.0	17.47

λ_1 64.

Cord. G.C. 7475

$\alpha = 6^h\,9^m\,5^s.1$; $\delta = -25°\,46'\,49''.0$

7.8, yellow ; 9.9, purple

t	θ_o	ρ_o
	°	″
1897.835	67.9	8.45
.835	67.5	8.42
1897.835	67.7	8.43

λ_1 65.

Cord. G.C. 7745

$\alpha = 6^h\,18^m\,52^s.5$; $\delta = -33°\,49'\,10''.6$

7.3, yellow ; 11.6, purple

1897.788	91.9	17.87
.788	92.2	17.80
1897.788	92.0	17.83

λ_1 66 = *Canopus* = *α Carinae.*

Cord. G.C. 7843

$\alpha = 6^h\,21^m\,43^s.6$; $\delta = -52°\,38'\,28''.2$

1, white ; 15, bluish

1897.025	160. ±	30. ±

A very faint companion noticed while searching with a screen.

λ_1 67.

Cord. DM. 23°3914

$\alpha = 6^h\,24^m\,52^s.2$; $\delta = -23°\,31'\,17''.2$

8.2, yellow ; 9.3, purplish

1897.835	214.6	2.48
.835	214.0	2.71
1897.835	214.3	2.60

A small close system.

λ_1 68 = *ξ_1 Canis Majoris.*

Cord. G.C. 7989

$\alpha = 6^h\,27^m\,41^s.4$; $\delta = -23°\,20'\,48''.2$

A B

4.9, yellow ; 14.5, bluish

1897.835	146.8	24.83
.835	146.5	24.79
1897.835	146.6	24.81

C, 14, bluish.

A C

1897.835	303.0	29.02
.835	303.3	28.79
1897.835	303.1	28.91

Faint companions of a bright star.

λ_1 69.

Cord. G.C. 8079

$\alpha = 6^h\,31^m\,2^s.5$; $\delta = -42°\,1'\,7''.1$

7.8, or. yellow ; 13.3, bl. purple

1897.148	7.1	[10.33]
.159	8.1	11.56
.159	7.2	11.89
1897.156	7.5	11.72

Companion difficult, system of minor interest.

λ_1 70.

Cord. G.C. 8274

$\alpha = 6^h\,37^m\,23^s.7$: $\delta = -52°\,44'\,21''.8$

7.6, or. yellow : 7.7, or. yellow

t	θ_0	ρ_0
	°	″
1897.011	117.7	[1.23?]
.074	115.6	0.46
.074	118.4	0.45
1897.053	117.1	0.46

Fine system.

λ_1 71 = G 86 *Canis Majoris.*

Cord. G.C. 8597

$\alpha = 6^h\,48^m\,59^s.6$: $\delta = -26°\,49'\,57''.3$

A B

6, orange : 14.7, bluish

1897.843	100.1	10.58
.843	101.0	10.70
1897.843	100.5	10.64

Companion difficult. *C*, 14.5, bluish.

A C

1897.843	215.8	20.51

λ_1 72.

O.A. 5901.

$\alpha = 6^h\,51^m\,18^s.1$: $\delta = -21°\,54'\,30''.7$

7, yellow ; 12.3, bl. purple

1897.835	39.5	13.77
.835	38.4	13.48
1897.835	39.0	13.63

λ_1 73.

Cord. G.C. 8777

$\alpha = 6^h\,55^m\,36^s.3$: $\delta = -27°\,45'\,12''.6$

7.9, yellow : 8, yellow

1897.772	348.5	0.27 est. 0″.19
.772	343.6	0.27
1897.772	346.1	0.27

Fine system, not quite separated.

λ_1 74.

Cord. G.C. 8787

$\alpha = 6^h\,56^m\,4^s.4$; $\delta = -21°\,58'\,45''.1$

6, yellow ; 14.7, bluish

1897.835	230.6	13.67
.835	230.3	13.88
1897.835	230.4	13.77

Companion very difficult.

Another system north by 128″.4 as follows:

1897.835	348.2	1.82
.835	348.1	1.90
1897.835	348.2	1.86

Magnitudes 10.5, 12; both bl. yellow.

λ_1 75.

Cord. G.C. 9284

$\alpha = 7^h\,13^m\,41^s.2$: $\delta = -25°\,48'\,20''.9$

6.5, yellow : 13.7, bluish

t	θ_0	ρ_0
	°	″
1897.843	7.5	12.42
.843	6.9	12.30
1897.843	7.2	12.36

Faint companion.

λ_1 76 = G 158 *Canis Majoris.*

Cord. G.C. 9374

$\alpha = 7^h\,16^m\,51^s.4$: $\delta = -26°\,46'\,35''.3$

6, yellow ; 15 purplish or dingy

1896.843	218.6	5.95
1897.159	214.7	8.93
.159	215.8	8.97
1897.054	216.4	7.95

A very remarkable object shining with an obscure dingy or purplish light. Extremely difficult.

λ_1 77.

Cord. Z.C. 7^h1222

$\alpha = 7^h\,18^m\,19^s.1$; $\delta = -36°\,26'\,10''.7$

8, yellow : 9.2, yellow

1897.230	303.4	0.41
.230	300.7	0.39
1897.230	302.0	0.40

Elegant system well separated.

λ_1 78.

Cord. G.C. 9444

$\alpha = 7^h\,18^m\,51^s.3$; $\delta = -25°\,34'\,31''.2$

A B

6, orange ; 12.8, purple

1897.843	288.7	2.38
.843	288.2	2.30
1897.843	288.4	2.34

C, 12. purple.

A C

1897.843	13.6	2.98

D, 12.4. purplish.

A D

1897.843	29.9	6.86

A curious quadruple.

λ_1 79.

Cord. Z.C. 7^h1506

$\alpha = 7^h\,22^m\,15^s.7$; $\delta = -27°\,57'\,45''.2$

7.9, yellow ; 8.3, yellow

1897.856	297.1	0.38 est. 0″.35
.856	296.4	0.35
1897.856	296.7	0.36

Fine, close system.

λ_1 80.

Cord. G.C. 9660

$\alpha = 7^h\,26^m\,47^s.7$; $\delta = -27°\,53'\,9''.9$

7.9, yellow ; 8.1, yellow

t	θ_0	ρ_0
	°	″
1897.829	85.3	0.25 est. 0″.23
.829	86.9	0.25
1897.829	86.1	0.25

Excessively close system, barely divided with 1000.

λ_1 81.

O.A. 7042

$\alpha = 7^h\,30^m\,14^s.8$; $\delta = -21°\,5'\,16''.0$

7.3, yellow ; 9. purple

1897.835	38.3	9.07
.835	38.6	9.20
1897.835	38.4	9.13

λ_1 82.

Cord. Z.C. 7^h2076

$\alpha = 7^h\,30^m\,15^s.8$; $\delta = -36°\,9'\,36''.3$

8.9, yellow ; 9.5, yellow

1897.137	347.5	7.49
.137	347.1	7.52
.142	348.5	7.15
.142	348.5	7.05
.159	347.8	7.21
1897.144	347.9	7.28

A faint pair near a bright star.

λ_1 83.

Cord. G.C. 9767

$\alpha = 7^h\,30^m\,59^s.3$; $\delta = -25°\,53'\,57''.6$

7, yellow ; 12.3, bluish

1897.843	200.6	8.87
.843	200.0	9.16
1897.843	200.3	9.01

λ_1 84 = G 111 *Puppis.*

Cord. G.C. 9913

$\alpha = 7^h\,35^m\,49^s.7$: $\delta = -19°\,25'\,48''.5$

5.8, or. yellow ; 11, purple

1897.824	287.4	9.37
.824	287.5	9.17
1897.824	287.4	9.27

λ_1 85 = G 155 *Puppis.*

Cord. G.C. 10025

$\alpha = 7^h\,39^m\,30^s.3$; $\delta = -28°\,10'\,24''.1$

5, orange ; 13.7, purple

1897.856	32.6	26.49
.856	32.6	26.87
1897.856	32.6	26.68

Interesting, faint companion to bright star.

λ_1 86 = *o Puppis.*

Cord. G.C. 10182

$\alpha = 7^h\, 43^m\, 56^s.0$: $\delta = -25^\circ\, 41'\, 20''.1$

5.4, yellow ; 13.9, purple

t	θ_0	ρ_0
	°	″
1897.829	197.4	27.86
.829	198.5	27.52
1897.829	198.0	27.69

λ_1 87 = G 192 *Puppis.*

Cord. G.C. 10236

$\alpha = 7^h\, 45^m\, 21^s.9$; $\delta = -19^\circ\, 57'\, 5''.8$

6, yellow ; 14.8, purplish or dingy

1897.835	144.3	4.51
.835	144.7	4.43
1897.835	144.5	4.47

Interesting and very difficult.

λ_1 88 = G 60 *Carinae.*

Cord. G.C. 10301

$\alpha = 7^h\, 46^m\, 57^s.9$: $\delta = -56^\circ\, 9'\, 28''.4$

6.5, or. yellow ; 15, dingy or ultra violet

1897.022	190.7	5.47
.088	185. ±	5.80 ±
.096	181.4	5.98
.096	183.2	5.79
1897.075	185.1	5.76

A most remarkable object shining with a dull obscure luster, as if by reflected light. A test object for telescopes and atmosphere in the southern hemisphere.

λ_1 89 = G 6 *Puppis.*

Cord. G.C. 10350

$\alpha = 7^h\, 49^m\, 6^s.4$; $\delta = -38^\circ\, 36'\, 11''.7$

5.5, yellow ; 13, bl. purple

1897.137	80.7	11.08
.137	81.0	11.21
.159	82.8	10.90
1897.145	81.5	11.06

Fine, brilliant system.

λ_1 90.

Cord. DM. 22°5387

$\alpha = 7^h\, 51^m\, 57^s.6$; $\delta = -22^\circ\, 5'\, 7''.1$

8.1, yellow ; 13.5, purple

1897.856	327.6	2.50
.856	328.7	2.38
1897.856	328.1	2.44

An elegant system.

λ_1 91 = G 223 *Puppis.*

Cord. G.C. 10454

$\alpha = 7^h\, 52^m\, 31^s.7$; $\delta = -43^\circ\, 34'\, 45''.1$

6.9, yellow ; 7, yellow

1897.162	301.5	0.41
.162	303.3	0.37
1897.162	302.4	0.39

Splendid system of highest interest.

λ_1 92 = *N Puppis.*

Cord. G.C. 10496

$\alpha = 7^h\, 54^m\, 4^s.2$; $\delta = -43^\circ\, 50'\, 27''.5$

A B

5.6, yellow ; 14, bluish

t	θ_0	ρ_0	
	°	″	
1897.082	[25. ±]	[11. ±]	
.134	37.0	9.58	
.134	37.9	9.77	
.159	32.7	10.04	Triple
1897.143	35.8	9.80	

C, 14.5, bluish.

A C

1897.159	87.5	22.86

After *B* had been discovered at Mexico, I learned that it had been seen independently at Arequipa sometime before. The component *C* makes *N Puppis* an interesting triple.

λ_1 93 = G 233 *Puppis.*

Cord. G.C. 10534

$\alpha = 7^h\, 55^m\, 22^s.1$; $\delta = -48^\circ\, 58'\, 25''.1$

A B = Hargrave

5.9, yellow ; 13.5, purple

1897.134	73.8	6.99
.137	73.0	7.03
.151	69.8	6.53
1897.140	72.2	6.85

C, 14, purplish.

A C = *h* 4025

1897.137	52.5	18.83
.151	47.2	18.54
1897.144	49.9	18.69

D, 11.5, purplish.

A D = *h* 4025.

1897.137	37.7	38.77
.151	37.3	39.36
1897.144	37.5	39.06

E, 13.9, purplish.

D E = λ_1 93

1897.137	68.3	10.66
.151	63.1	10.99
1897.144	65.7	10.82

Quintuple! Probably a complicated physical system; the only stellar system I know of constructed on a plan in any way analogous to that of the planets.

λ_1 94.

Cord. Z.C. 7h4148

$\alpha = 7^h\, 55^m\, 50^s.7$; $\delta = -47^\circ\, 24'\, 53''.9$

8, yellow ; 9.2, bl. yellow

1897.164	343.6	1.33
.164	343.3	1.27
1897.164	343.4	1.30

Superb, close system.

λ_1 95 = G 252 *Puppis.*

O.A. 8009

$\alpha = 8^h\, 2^m\, 53^s.2$; $\delta = -20^\circ\, 15'\, 53''.4$

6.5, yellow ; 14.9, bluish

t	θ_0	ρ_0
	°	″
1897.835	191.3	13.82
.835	191.8	13.87
1897.835	191.6	13.84

A very difficult object.

λ_1 96 = G 14 *Velorum.*

Cord. G.C. 10953

$\alpha = 8^h\, 9^m\, 20^s.5$; $\delta = -45^\circ\, 57'\, 18''.1$

7, yellow ; 7.3, yellow

1897.167	285. ±	0.20
.233	280. ±	0.30 ±
.233	278. ±	0.28
1897.211	281.0	0.26

Fine, close system.

λ_1 97.

Cord. Z.C. 8h746

$\alpha = 8^h\, 10^m\, 5^s.8$; $\delta = -37^\circ\, 25'\, 18''.2$

A B

7, yellow ; 13.5, bl. purple

1897.230	1.4	3.06
.230	1.6	3.23
1897.230	1.5	3.14

C, 14, bluish.

A C

1897.230	15.5	16.01

λ_1 98 *C.*

Cord. G.C. 11904

$\alpha = 8^h\, 11^m\, 9^s.4$; $\delta = -35^\circ\, 23'\, 3''.9$

7, yellow ; 13.5, purplish

1897.200	72.3	4.54	C
1897.211	73.2	4.97	See

Interesting and difficult companion. Afterwards independently discovered by INNES.

λ_1 99.

Cord. Z.C. 8h1560

$\alpha = 8^h\, 19^m\, 36^s.3$; $\delta = -47^\circ\, 52'\, 35''.1$

8, yellow ; 11.9, bl. yellow

1897.225	114.1	5.65
.225	114.5	5.59
1897.225	114.3	5.62

The n.f. of a wide double, distant 70″.±

λ_1 100.

Cord. G.C. 11287

$\alpha = 8^h\, 20^m\, 31^s.3$; $\delta = -57^\circ\, 33'\, 59''.2$

7.8, yellow ; 12.8, bl. purple

1897.025	308.5	8.17
.088	309.3	7.31
.088	309.9	7.80
1897.067	309.2	7.76

λ_1 101.

Cord. G.C. 11680

$\alpha = 8^h\ 35^m\ 11^s.7$: $\delta = -28°\ 1'\ 31''.2$

8, yellow : 11.8, purple

t	θ_0	ρ_0
	°	″
1897.829	91.1	7.17
.829	92.0	7.25
1897.829	91.5	7.21

λ_1 102.

Cord. G.C. 11699

$\alpha = 8^h\ 35^m\ 37^s.3$: $\delta = -39°\ 26'\ 42''.6$

7.2, yellow : 7.8, yellow

1897.184	240.9	0.44 est. 0″.4

Fine close system.

λ_1 103.

Cord. G.C. 11797

$\alpha = 8^h\ 39^m\ 2^s.1$: $\delta = -47°\ 44'\ 23''.4$

7.1, yellow : 13.1, bluish

1897.082	[200. ±]	[10. ±]
.137	206.6	14.21
.137	206.1	13.98
.197	208.4	14.23
1897.157	207.1	14.14

A third star in 185°, 35″.

λ_1 104.

Cord. G.C. 11803

$\alpha = 8^h\ 39^m\ 20^s.9$: $\delta = -47°\ 48'\ 12''.1$

8.5, yellow ; 11.5, yellow

1897.197	174.9	8.90

λ_1 105.

Cord. DM. 26°6411

$\alpha = 8^h\ 41^m\ 19^s.2$; $\delta = -26°\ 46'\ 39''.7$

A B

7, or. yellow ; 14.5, bluish

1897.856	116.7	22.99

C, 14.5, bluish.

A C

1897.856	146.2	22.98

D, 14.5, bluish.

A D

1897.856	246.3	22.93

λ_1 106.

Cord. G.C. 11980

$\alpha = 8^h\ 45^m\ 35^s.6$: $\delta = -23°\ 34'\ 49''.1$

A B

6, or. yellow ; 12, bl. purple

1897.835	224.6	17.43
.835	224.3	17.51
1897.835	224.4	17.17

C, 13, bl. purple.

λ_1 106 (cont.)

B C

t	θ_0	ρ_0
	°	″
1897.835	333.2	3.24
.835	332.9	3.25
1897.835	333.0	3.24

A curious triple system, with double companion.

λ_1 107 = δ *Pyxidis.*

Cord. G.C. 12132

$\alpha = 8^h\ 51^m\ 13^s.9$: $\delta = -27°\ 17'\ 45''.1$

6, yellow : 14.5, bluish

1897.856	267.5	23.85

Faint companion to bright star.

λ_1 108 *C.*

Cord. G.C. 12268

$\alpha = 8^h\ 56^m\ 43^s.7$: $\delta = -42°\ 46'\ 58''.3$

7.7, yellow ; 13, purple

1897.186	14.8	2.70	C
1897.192	46.8	2.89	See

Elegant physical system.

λ_1 109 = λ *Velorum.*

Cord. G.C. 12438

$\alpha = 9^h\ 4^m\ 19^s.1$: $\delta = -43°\ 1'\ 44''.0$

2.5, or. red ; 14.8, bluish

1897.151	130. ±	16. ±
.159	137.4	18.22
1897.155	133.7	17.11

Very faint companion: system resembles that of *Aldebaran*, and is equally difficult.

λ_1 110 *C.*

Cord. G.C. 12528

$\alpha = 9^h\ 8^m\ 11^s.0$: $\delta = -46°\ 28'\ 32''.6$

8.2, yellow : 8.5, yellow

1897.025	45.2	1.28	C
.164	49.6	0.85	C
1897.094	47.4	1.06	
1897.120	[60. ±]	0.7 ±	See
.164	50.9	0.67	See
1897.142	50.9	0.69	

Elegant system: afterwards noted independently by Innes.

λ_1 111 = κ *Velorum.*

Cord. G.C. 12620

$\alpha = 9^h\ 11^m\ 45^s.0$; $\delta = -36°\ 59'\ 46''.9$

6.2, or. yellow : 14.5, bluish

1897.375	127.5	11.11
.375	123.9	11.43
1897.375	125.7	11.27

Very difficult.

λ_1 112.

Cord. G.C. 12922

$\alpha = 9^h\ 24^m\ 50^s.6$; $\delta = -45°\ 3'\ 38''.5$

7.4, yellow : 13.2, bluish

t	θ_0	ρ_0
	°	″
1897.028	273.5	9.72
.041	267.2	[7.13]
.120	264.9	8.98
1897.063	268.5	9.35

Very difficult system.

λ_1 113 = G 3 *Antliae.*

Cord. G.C. 12942

$\alpha = 9^h\ 25^m\ 28^s.2$; $\delta = -26°\ 9'\ 4''.8$

6, or. yellow : 14.8, dingy

1897.856	177.5	3.96
.856	178.7	4.30
1897.856	178.1	4.13

Exceedingly difficult and obscure companion.

λ_1 114 = G 11 *Antliae.*

Cord. G.C. 13003.

$\alpha = 9^h\ 27^m\ 22^s.4$: $\delta = -35°\ 16'\ 4''.0$

A B

6.9, or. yellow ; 13.9, bluish

1897.375	283.1	23.08
.375	283.5	24.19
1897.375	283.3	23.63

C, 15, bluish.

B C

1897.375	232.0	4.13
.375	233.7	4.15
1897.375	232.8	4.14

Excessively difficult.

λ_1 115 = G 150 *Velorum.*

Cord. G.C. 13157.

$\alpha = 9^h\ 33^m\ 52^s.2$: $\delta = -53°\ 13'\ 5''.7$

6.5, yellow ; 6.5, yellow

1897.192	192.5	0.30
.211	176. ±	0.20
1897.201	184.3	0.25

Close system of great interest.

λ_1 116.

Cord. Z.C. 9h3158

$\alpha = 9^h\ 41^m\ 43^s.7$; $\delta = -28°\ 6'\ 37''.4$

8.1, yellow : 10.8, purple

1897.856	200.5	2.84
.856	200.0	2.88
1897.856	200.3	2.86

λ_1 117.

Cord. Z.C. 9h4313

$\alpha = 9^h\ 57^m\ 7^s.9$: $\delta = -43°\ 3'\ 37''.0$

8.5, yellow : 14, bluish

1897.225	336.3	13.36
.225	335.2	13.47
1897.225	335.7	13.41

λ_1 118 = G 195 *Velorum.*

Cord. G.C. 13998

$\alpha = 10^h\,11^m\,27^s.9$; $\delta = -55^\circ\,3'\,8''.2$

6.9, yellow ; 13.3, purplish

t	θ_o	ρ_o
	°	″
1897.028	148.5	12.82
.128	148.2	13.43
.128	148.6	14.04
1897.095	148 4	13.43

λ_1 119 = *p Velorum.*

Cord. G.C. 14517

$\alpha = 10^h\,33^m\,6^s.1$; $\delta = -47^\circ\,42'\,21''.1$

4.6, yellow ; 5.2, yellow

1897.025	275.0	0.42	
.085	265.5	0.48	
.085	266.3	0.52	
1897.065	268.9	0.47	
1897.085	261.4	0.66	C

Splendid, close system, resembling *β Delphini;* an object of the highest importance. Barely divided with high powers on the great telescope: estimated distance 0″.33.

λ_1 120.

Cord. Z.C. 10h2675

$\alpha = 10^h\,37^m\,50^s.1$; $\delta = -33^\circ\,7'\,57''.5$

8, yellow ; 14, purple

1897.381	290.7	5.49
.381	290.7	5.49
1897.381	290.7	5.49

Interesting system.

λ_1 121 = G 78 *Antliae.*

Cord. G.C. 14635

$\alpha = 10^h\,38^m\,4^s.1$; $\delta = -32^\circ\,11'\,31''.5$

6, yellow ; 14.8, bluish

1897.381	220 2	18.09
.381	220.0	18.04
1897.381	220.1	18.06

Excessively difficult.

λ_1 122.

Anon.

$\alpha = 10^h\,38^m\,21^s.1$; $\delta = -59^\circ\,26'\,33''.3$

A B

10.4, yellow ; 11.7, yellow

1897.181	349.2	2.88
.181	348.3	3.12
.184	347.1	2.74
.184	345.2	3.44
1897.183	347.5	3.05

C, 12.9, bl. yellow.

λ_1 122 (cont.)

A C = *h* 4348

t	θ_o	ρ_o
	°	″
1897.181	259.3	13.84
.181	259.9	13.89
.184	259.6	14.24
.184	259.5	14.03
1897.183	259.6	14.00

There are no other measures of the Herschel star, *h* 4348, and the close pair is new.

λ_1 123.

G 83 Cat. *η Carinae*

$\alpha = 10^h\,40^m\,7^s.9$; $\delta = -59^\circ\,0'\,55''.0$

9.4, yellow ; 13. bl. yellow

1897.175	306.8	4.17
.175	307.2	4.11
.178	305.4	3.55
.181	303.1	3.37
1897.177	305.6	3.80

No. 83 in Gould's Catalogue of the Cluster of *η Carinae.*

λ_1 124 *C.*

Cord. Z.C. 10h2943

$\alpha = 10^h\,41^m\,21^s.4$; $\delta = -53^\circ\,17'\,55''.4$

7, yellow ; 13, purple

1897.088	359.6	8.83	C
1897.175	359.8	10.57	See
.175	360.6	10.49	See
1897.175	360.2	10.53	

The measures of distance are very inconsistent.

λ_1 125.

Cord. Z.C. 10h3370

$\alpha = 10^h\,47^m\,18^s.4$; $\delta = -44^\circ\,33'\,20''.3$

9.2, yellow ; 11.2, yellow

1897.227	198.7	1.93
.227	198.9	1.66
1897.227	198.8	1.80

Interesting, faint system.

λ_1 126.

Cord. G.C. 15049

$\alpha = 10^h\,55^m\,38^s.1$; $\delta = -42^\circ\,51'\,10''.8$

7.9, yellow ; 8.4, yellow

1897.192	167.9	0.86
.211	172.0	0.71
.211	171.1	0.60
1897.205	170.3	0.72

Close system, well separated.

λ_1 127.

Anon., near Cord. Z.C. 10h4036

$\alpha = 10^h\,56^m\,48^s.7$; $\delta = -53^\circ\,0'\,56''.3$

8.7, yellow ; 9.5, yellow

t	θ_o	ρ_o
	°	″
1897.225	320.1	6.81
.225	319.8	6.95
1897.225	320.0	6.88

Place is that of Z.C. 4036; system is s.f. 130 , 110″.

λ_1 128.

Cord. G.C. 15398

$\alpha = 11^h\,10^m\,23^s.6$; $\delta = -38^\circ\,55'\,54''.8$

7.9, yellow ; 7.9, yellow

1897.433	209.3	0.55 est. 0″.35
.433	206.9	0.49
1897.433	208.1	0.52

Fine, close system.

λ_1 129.

Cord. G.C. 15561

$\alpha = 11^h\,17^m\,55^s.2$; $\delta = -52^\circ\,49'\,17''.1$

7.6, yellow ; 13.1, bl. purple

1897.088	5.1	6.64
.088	4.5	6.71
.120	2.8	6.92
1897.099	4.1	6.76

λ_1 130.

Cord. G.C. 15566

$\alpha = 11^h\,18^m\,11^s.0$; $\delta = -35^\circ\,50'\,47''.5$

8, yellow ; 8, yellow

1897.430	30.3	0.21
.430	27.6	0.19
1897.430	28.0	0.20

Excessively close system, resembling β 883.

λ_1 131 = G 26 *Centauri.*

Cord. G.C. 15571

$\alpha = 11^h\,18^m\,22^s.1$; $\delta = -35^\circ\,36'\,58''.2$

4.5, or. yellow ; 14.8, bl. purple

1897.373	128.7	31.79
.373	129.3	31.55
1897.373	129.0	31.67

Faint companion to bright star.

λ_1 132.

Cord. Z.C. 11h2360

$\alpha = 11^h\,34^m\,47^s.7$; $\delta = -52^\circ\,10'\,34''.1$

7.7, yellow ; 14, bluish

1897.225	69.7	11.42
.225	69.3	12.01
1897.225	69.5	11.71

λ_1 133 = G 295 *Hydrae.*

Cord. G.C. 15986

$\alpha = 11^h 36^m 44^s.3$: $\delta = -31° 56' 37''.7$

5.6, deep orange ; 13.9, bluish

t	θ_0	ρ_0
1897.416	346.0	26.82
.416	346.1	26.67
1897.416	346.1	26.74

λ_1 134.

Cord. G.C. 16021

$\alpha = 11^h 38^m 13^s.3$: $\delta = -51° 53' 15''.7$

7.9, yellow : 14, bluish

1897.225	323.5	12.14
.225	323.4	12.29
1897.225	323.4	12.21

λ_1 135 = G 297 *Hydrae.*

Cord. G.C. 16114

$\alpha = 11^h 42^m 16^s.4$: $\delta = -29° 43' 22''.0$

7, yellow : 7, yellow

1897.416	185. ±	0.20 ±

Clearly elongated but not separated: nice, close system.

λ_1 136.

Cord. Z.C. 11^h2950

$\alpha = 11^h 43^m 54^s.6$: $\delta = -35° 22' 40''.2$

9.5, yellow : 13.5, bluish

1897.373	263.2	7.52
.373	261.9	8.17
1897.373	262.5	7.84

λ_1 137.

Anon.

$\alpha = 11^h 47^m 10^s.$: $\delta = -43° 23' 21''$

8.1, yellow : 9, yellow

1897.225	347.1	1.22
.225	348.1	1.23
1897.225	347.6	1.22

Nice, close system.

λ_1 138.

Cord. G.C. 16214

$\alpha = 11^h 47^m 42^s.8$: $\delta = -48° 6' 30''.4$

7.6, yellow ; 11.6, bluish

1897.131	171.8	2.24
.131	173.2	2.26
.167	172.3	2.41
1897.143	173.1	2.20

The n.f. star of a wide double. A very interesting system.

λ_1 139.

Cord. G.C. 16244

$\alpha = 11^h 49^m 9^s.9$: $\delta = -37° 2' 34''.6$

7.8, yellow : 12, purple

t	θ_0	ρ_0
		″
1897.147	38.7	0.84
.147	37.8	0.92
1897.147	38.2	0.88

Very difficult and very interesting close system.

λ_1 140 = G 81 *Centauri.*

Cord. G.C. 16301

$\alpha = 11^h 51^m 41^s.9$: $\delta = -46° 30' 58''.4$

7.6, yellow : 11, bluish

1897.096	198.2	0.75
.120	198.0	1.14
.120	199.3	0.98
1897.112	198.5	0.96

Close system, separated with difficulty on account of the inequality of the components.

λ_1 141.

Cord. G.C. 16345

$\alpha = 11^h 53^m 15^s.7$: $\delta = -40° 25' 28''.0$

7, yellow ; 10.8, purple

1897.436	309.3	3.30
.436	309.9	3.52
1897.436	309.6	3.41

Physical system.

λ_1 142 = G 310 *Hydrae.*

Cord. G.C. 16423

$\alpha = 11^h 56^m 41^s.1$: $\delta = -34° 5' 38''.5$

7.6, yellow : 8.8, yellow

1897.130	236.3	0.86
.130	238.6	0.86
1897.130	237.4	0.86

Fine, close system of high interest: independently discovered by INNES.

λ_1 143 = G 89 *Centauri.*

Cord. G.C. 16460

$\alpha = 11^h 58^m 32^s.5$: $\delta = -38° 27' 2''.4$

7.2, yellow : 7.4, yellow

1897.197	225.1	0.73
.197	225.8	0.72
1897.197	225.4	0.72

Important, close system nicely separated.

λ_1 144 = G 311 *Hydrae.*

Cord. G.C. 16512

$\alpha = 12^h 0^m 48^s.4$; $\delta = -35° 8' 14''.0$

6, yellow : 14.8, bluish

1897.373	177.1	26.20
.373	177.5	26.06
.430	173.4	24.78
.430	174.8	24.89
1897.401	175.7	25.48

Companion very difficult.

λ_1 145 = G 97 *Centauri.*

Cord. G.C. 16622

$\alpha = 12^h 5^m 22^s.5$; $\delta = -37° 18' 48''.6$

7, yellow ; 9, bl. yellow

t	θ_0	ρ_0
	°	″
1897.427	49.1	0.70 ±

Fine system of unequal stars.

λ_1 146.

Cord. G.C. 16623

$\alpha = 12^h 5^m 25^s.8$; $\delta = -36° 16' 40''.8$

8, yellow ; 12.2, purple

1897.386	59.7	0.64
.386	56.4	0.68
1897.386	58.1	0.66

λ_1 147.

Cord. G.C. 16705

$\alpha = 12^h 8^m 54^s.3$; $\delta = -36° 10' 20''.6$

A B

7, yellow : 7.1, yellow

1897.430	23.0	0.19 ±
.430	18.1	0.20 ±
1897.430	20.5	0.19

Excessively close, elongated as 4:6; no trace of separation.

C, 13, bluish.

$\frac{AB}{2}, C$

1897.430	302.5	30.73
.430	302.5	30.61
1897.430	302.5	30.67

λ_1 148.

Cord. Z.C. 12^h492

$\alpha = 12^h 8^m 54^s.8$: $\delta = -35° 59' 59''.1$

6.5, yellow : 13.5, bluish

1897.430	63.5	20.40
.430	63.1	20.52
1897.430	63.3	20.46

Large star appears to be a close double: 41°.5, 0″.2 ±.

λ_1 149.

Cord. Z.C. 12^h911

$\alpha = 12^h 15^m 56^s.8$: $\delta = -44° 49' 49''.6$

8.2, yellow ; 8.3, yellow

1897.436	305.6	0.59
.436	305.7	0.59
1897.436	305.7	0.59

Fine, close system, would separate if not at so low an altitude (9°).

λ_1 150 = G 320 *Hydrae.*

Cord. G.C. 16897

$\alpha = 12^h 18^m 33^s.3$: $\delta = -29° 46' 50''.6$

6, or. yellow ; 13.5, bl. purple

1897.375	102.9	17.58
.375	102.1	18.34
1897.375	102.5	17.86

λ_1 151 = x_2 *Centauri.*

Cord. G.C. 16929

$\alpha = 12^h\,20^m\,5^s.8$; $\delta = -34°\,37'\,55''.8$

7, yellow ; 7.2, yellow

t	θ_o	ρ_o
	°	″
1897.427	40. ±	0.18 ±
.479	42.8	0.26
1897.453	41.4	0.22

Excessively close double, not quite separated with 1500.

λ_1 152.

Cord. G.C. 16931

$\alpha = 12^h\,20^m\,8^s.7$; $\delta = -30°\,34'\,34''.2$

7.7, yellow ; 12, purple

1897.381	87.2	2.20
.381	87.0	2.51
1897.381	87.1	2.35

λ_1 153.

Cord. G.C. 16937

$\alpha = 12^h\,20^m\,39^s.4$; $\delta = -49°\,2'\,4''.4$

7.6, yellow ; 12.8, bluish

1897.131	203.4	14.13
.131	202.9	13.87
.164	202.6	13.21
1897.142	203.0	13.74

λ_1 154 = *G Centauri*

Cord. G.C. 16946

$\alpha = 12^h\,21^m\,7^s.8$; $\delta = -50°\,53'\,46''.4$

4.3, yellow ; 13.8, bluish

1897.128	285.7	23.66
.128	285.8	23.28
.167	285.0	23.57
1897.141	285.5	23.50

λ_1 155.

Cord. DM. 34°8203

$\alpha = 12^h\,24^m\,38^s.8$; $\delta = -34°\,14'\,13''.0$

9, yellow ; 12, purple

1897.381	118.7	10.22
.381	118.4	10.22
1897.381	118.5	10.22

λ_1 156.

Cord. Z.C. 12^h1789

$\alpha = 12^h\,30^m\,45^s.6$; $\delta = -35°\,16'\,23''.1$

8.3, yellow ; 8.8, yellow

1897.383	123.3	0.53
.383	125.7	0.57
.389	122.0	0.49
.389	122.5	0.45
1897.386	123.4	0.51

Fine close system.

λ_1 157 = G 130 *Centauri.*

Cord. G.C. 17157

$\alpha = 12^h\,31^m\,16^s.4$; $\delta = -49°\,47'\,1''.7$

6.3, yellow ; 13.3, bl. purple

t	θ_o	ρ_o
	°	″
1897.140	121.1	7.64
.140	120.0	7.56
.167	122.7	7.79
1897.149	121.3	7.66

Companion difficult.

λ_1 158 *C.*

Cord. G.C. 17204

$\alpha = 12^h\,33^m\,17^s.5$; $\delta = -38°\,50'\,32''.4$

9, or. yellow ; 11, bluish

1897.085	191.6	0.99 C est. 1″.0

Difficult.

λ_1 159 = γ *Centauri.*

Cord. G.C. 17269

$\alpha = 12^h\,36^m\,0^s.4$; $\delta = -48°\,24'\,35''.3$

C, 14.5, bluish.

$\frac{AB}{2}, C$

1897.140	121.7	29.78

A third component, very difficult.

AB = *h* 4539; mags. 4; 4, yellow

1897.041	356.4	1.88
.128	359.6	2.01
.128	360.2	1.98
1897.100	358.7	1.97

λ_1 160.

Cord. DM. 38°7979

$\alpha = 12^h\,40^m\,58^s.9$; $\delta = -38°\,53'\,58''.8$

10, yellow ; 11.5, purple

1897.419	175.6	1.50
.419	175.7	1.60
1897.419	175.6	1.55

λ_1 161.

Cord. G.C. 17429

$\alpha = 12^h\,42^m\,40^s.6$; $\delta = -35°\,9'\,35''.2$

A B

7.5, yellow ; 12.3, bl. yellow

1897.381	109.1	33.79
.381	109.1	34.13
1897.381	109.1	33.96

C, 13.3, bl. yellow.

B C

1897.381	94.2	6.17
.381	94.3	6.03
1897.381	94.2	6.10

λ_1 162.

Cord. DM. 34°8441

$\alpha = 12^h\,44^m\,0^s.6$; $\delta = -34°\,12'\,57''.4$

11, yellow ; 13.8, bluish

t	θ_o	ρ_o
	°	″
1897.386	229.0	5.64
.386	228.4	5.80
.430	228.6	4.32
.430	227.5	4.71
1897.408	228.4	5.12

λ_1 163 = ρ *Centauri.*

Cord. G.C. 17473

$\alpha = 12^h\,45^m\,15^s.7$; $\delta = -33°\,27'\,13''.2$

4, yellow ; 15, bluish

1897.395	60.3	27.58(?) est. 22″

Companion very difficult.

λ_1 164.

Cord. Z.C. 12^h2686

$\alpha = 12^h\,46^m\,18^s.7$; $\delta = -32°\,48'\,2''.2$

A B

8.5, yellow ; 14.4, purplish

1897.386	193.7	2.57
.386	191.9	2.54
.395	187.1	2.38
.395	186.4	2.36
1897.391	189.7	2.46

Extremely difficult.

C, 14.8, bluish.

A C

1897.386	120.1	44.04
386	119.0	42.46
1897.386	119.6	43.25

Very difficult.

λ_1 165.

Cord. G.C. 17514

$\alpha = 12^h\,47^m\,42^s.1$; $\delta = -38°\,50'\,47''.4$

6.5, or. yellow ; 14.5, bluish

1897.373	235.9	21.35
.373	233.4	21.00
1897.373	234.7	21.17

λ_1 166.

Cord. Z.C. 12^h3085

$\alpha = 12^h\,53^m\,32^s.4$; $\delta = -40°\,26'\,58''.8$

7.9, yellow ; 13, purple

1897.389	348.6	20.41
.389	348.6	20.31
1897.389	348.6	20.36

λ_1 167 C

Cord. Z.C. 12^h3188

$\alpha = 12^h\,55^m\,11^s.5$: $\delta = -35°\,36'\,42''.5$

8, yellow : 13, bluish

t	θ_0	ρ_0	
	°	″	
1897.447	116.5	23.68	C
.447	118.5	23.70	C
1897.447	117.5	23.69	C
1897.447	116.7	24.03	See

λ_1 168.

Cord. DM. 38 8203

$\alpha = 12^h\,58^m\,2^s.4$: $\delta = -38°\,24'\,54''.0$

8.2, yellow : 8.2, yellow

1897.422	182.2	0.25 est. 0″.25
.422	184.1	0.25
1897.422	183.1	0.25

Important close system.

λ_1 169.

Cord. G.C. 17757

$\alpha = 12^h\,58^m\,15^s.0$: $\delta = -33°\,43'\,46''.2$

7, or. yellow ; 13.4, bl. purple

1897.386	235.8	11.18
.386	235.3	11.29
.414	236.4	10.93
.414	236.4	11.15
.427	234.6	10.89
.433	235.7	10.99
.471	235.6	11.80
.471	236.3	11.51
1897.425	235.8	11.33

Difficult and interesting system.

λ_1 170 = G 183 *Centauri.*

Cord. G.C. 17936

$\alpha = 13^h\,6^m\,2^s.9$; $\delta = -59°\,23'\,16''.9$

7, or. yellow ; 7, or. yellow

1897.134	86. ±	0.35 ±
.135	88. ±	0.30 ±
.162	106.4	0.37
.162	105.1	0.34
1897.146	96.3	0.34

Fine close system of great interest.

The Harvard observers have noted a 12M companion in 260°, 30″.

λ_1 171.

Cord. G.C. 18014

$\alpha = 13^h\,9^m\,19^s.0$: $\delta = -34°\,6'\,3''.8$

8.1, yellow : 8.1, yellow

1897.427	303.1	0.44
.427	300.4	0.39
1897.427	301.7	0.41

Important close system.

λ_1 172.

Cord. G.C. 18025

$\alpha = 13^h\,9^m\,40^s.4$; $\delta = -33°\,37'\,25''.5$

A B

7.6, yellow ; 14.5, bl. purple

t	θ_0	ρ_0
	°	″
1897.386	346.7	4.75
.386	347.2	4.46
.414	346.1	4.64
.414	345.4	4.92
.427	348.5	3.87
.427	348.0	4.01
.471	347.6	4.77
.471	348.0	4.60
1897.424	347.2	4.50

Companion very difficult.

C, 14.9, bluish.

A C

1897.386	227.5	19.99

D, 15, bluish.

A D

1897.414	109.1	49.30

λ_1 173.

Cord. G.C. 18053

$\alpha = 13^h\,11^m\,2^s.4$; $\delta = -40°\,45'\,17''.0$

A B

8, yellow ; 13.8, purple

1897.400	115.7	3.15
.400	115.6	3.02
.419	111.4	3.13
.419	112.2	3.02
1897.410	113.5	3.08

C, 10, bl. yellow = G.C. 18054.

A C

1897.419	1.2	43.97

λ_1 174.

Cord. G.C. 18063

$\alpha = 13^h\,11^m\,21^s.1$; $\delta = -50°\,3'\,49''.9$

8.2, yellow : 8.2, yellow

1897.400	2.2	0.15 ±
.400	0.0	0.17 ±
1897.400	1.1	0.16 ±

Excessively close and difficult; fine system.

λ_1 175.

Cord. Z.C. 13^h712

$\alpha = 13^h\,12^m\,57^s.3$: $\delta = -31°\,34'\,39''.6$

A B

9, yellow : 13.3, bluish

1897.397	115.5	12.42
.397	115.3	12.53
1897.397	115.4	12.47

C, 13.5, bluish.

A C

1897.397	115.1	12.52

λ_1 176 = G 200 *Centauri.*

Cord. G.C. 18129

$\alpha = 13^h\,14^m\,13^s.1$; $\delta = -59°\,14'\,48''.5$

7.3, yellow : 13.6, purplish

t	θ_0	ρ_0
	°	″
1897.145	208.5	12.90
.145	208.2	12.66
.162	209.0	13.35
1897.147	208.6	12.97

λ_1 177.

Cord. G.C. 18249

$\alpha = 13^h\,19^m\,8^s.7$; $\delta = -34°\,6'\,49''.9$

7.9, yellow ; 8.5, yellow

1897.471	197.9	0.21 est. 0″.3
.471	198.9	0.20
1897.471	198.4	0.21

Close system of high interest.

λ_1 178.

Cord. Z.C. 13^h1209

$\alpha = 13^h\,21^m\,38^s.9$; $\delta = -32°\,12'\,48''.3$

8.1, yellow ; 14.0, bluish

1897.381	225.9	14.94
.381	225.2	14.68
1897.381	225.6	14.81

λ_1 179 = *d Centauri.*

Cord. G.C. 18376

$\alpha = 13^h\,25^m\,14^s.6$; $\delta = -38°\,53'\,27''.0$

5, orange ; 5, orange

1897.096	98. ±	0.18 ±
.120	104.7	0.20
.120	105.5	0.18
.389	280. ±	0.20 ±
.389	275. ±	0.20 ±
1897.223	104.8	0.19

Excessively close system of the highest interest: the closest of all our bright double stars. At Flagstaff this object was twice noticed as a double, without my knowing what it was; and as the star was only about 14° from the horizon, the result may be regarded as furnishing a satisfactory criterion for the steadiness of the atmosphere and for the definition of the great Clark refractor.

λ_1 180 = G 228 *Centauri.*

Cord. G.C. 18382

$\alpha = 13^h\,25^m\,29^s.3$; $\delta = -41°\,56'\,53''.3$

6, yellow ; 13.5, bl. purple

1897.233	230.6	3.90
.233	230.5	3.90
1897.233	230.5	3.90

Physical system of high interest.

λ_1 181.

Cord. Z.C. 13^h1589

$\alpha = 13^h\,27^m\,57^s.6$; $\delta = -37^\circ\,44'\,38''.1$

A B

8, yellow ; 8.3, yellow

t	θ_o	ρ_o
	°	″
1897.389	102.0	0.47 est. 0″.35
.389	101.9	0.39
1897.389	102.0	0.43

Fine system just separated.

C, 12.5, bl. yellow.

$\frac{AB}{2}, C$

1897.389	18.0	28.33
.389	18.4	28.33
1897.389	18.2	28.33

λ_1 182.

Cord. Z.C. 13^h1625

$\alpha = 13^h\,28^m\,32^s.0$; $\delta = -41^\circ\,53'\,22''.4$

8.3, yellow ; 11.2, bluish

1897.167	160.3	1.28
.167	160.9	1.45
1897.167	160.6	1.36

Afterwards noted independently by Innes.

λ_1 183.

Cord. G.C. 18528

$\alpha = 13^h\,31^m\,58^s.0$; $\delta = -31^\circ\,50'\,58''.6$

8.1, yellow ; 8.1, yellow

1897.395	260. ±	0.25 ±
.395	265. ±	0.25 ±
1897.395	262.5 ±	0.25 ±

Very close double, not quite divided.

λ_1 184 = G 241 *Centauri.*

Cord. G.C. 18531

$\alpha = 13^h\,32^m\,4^s.1$; $\delta = -34^\circ\,33'\,14''.0$

7.2, yellow ; 12, purplish

1897.044	[295. ±]	[1.0 ±]
1897.131	314.9	0.99
.131	316.0	0.94
.386	309.1	0.99
.386	308.6	1.04
1897.256	310.9	0.99

Fine unequal pair, resembling 85 *Pegasi.*

Afterwards independently noted by Innes.

λ_1 185.

Cord. Z.C. 13^h1862

$\alpha = 13^h\,32^m\,21^s.1$; $\delta = -36^\circ\,58'\,25''.1$

7, yellow ; 13, bluish

1897.373	13.3	17.64
.373	14.2	17.59
1897.373	13.8	17.61

λ_1 186 = G 353 *Hydrae.*

Cord. G.C. 18546

$\alpha = 13^h\,32^m\,45^s.5$; $\delta = -29^\circ\,15'\,48''.3$

8, yellow ; 8, yellow

t	θ_o	ρ_o
	°	″
1897.493	195.7	0.20 ±
.493	197.9	0.20
1897.493	196.8	0.20

Excessively close pair.

λ_1 187 C.

Cord. G.C. 18617

$\alpha = 13^h\,36^m\,37^s.4$; $\delta = -36^\circ\,52'\,14''.9$

8.8, yellow ; 12.8, purple

1897.447	33.2	3.77	C
.447	32.3	3.79	C
1897.447	32.7	3.78	
1897.447	33.2	4.01	See

Difficult system.

λ_1 188.

Cord. G.C. 18629

$\alpha = 13^h\,37^m\,7^s.1$; $\delta = -32^\circ\,9'\,54''.0$

7.2, yellow ; 12.3, purple

1897.381	275.3	18.27
.381	275.4	18.65
.395	275.1	19.02
.395	274.7	18.66
1897.388	275.1	18.65

λ_1 189.

Cord. G.C. 18843

$\alpha = 13^h\,46^m\,34^s.6$; $\delta = -30^\circ\,17'\,24''.5$

7.8, or. yellow ; 12.8, bl. purple

1897.460	256.5	13.29
.460	255.9	13.37
1897.460	256.2	13.33

λ_1 190.

Cord. Z.C. 13^h2864

$\alpha = 13^h\,48^m\,7^s.0$; $\delta = -29^\circ\,47'\,25''.9$

A B

7.1, or. yellow ; 11, bl. purple

1897.493	223.4	7.14
.493	222.1	7.11
1897.493	222.7	7.13

C, 13.2. bl. yellow.

A C

1897.493	144.1	32.03

λ_1 191.

Cord. G.C. 18891

$\alpha = 13^h\,48^m\,49^s.4$; $\delta = -34^\circ\,6'\,10''.3$

6.9, yellow ; 13.2, purplish

1897.473	155.6	19.54
.473	155.0	19.51
1897.473	155.3	19.52

λ_1 192.

Cord. G.C. 18923

$\alpha = 13^h\,50^m\,18^s.1$; $\delta = -38^\circ\,10'\,21''.9$

7.6, yellow ; 13, purple

t	θ_o	ρ_o
	°	″
1897.373	182.5	2.38
.373	183.4	2.19
1897.373	183.0	2.28

Physical system.

Independently discovered by Innes.

λ_1 193.

Cord. G.C. 18941

$\alpha = 13^h\,51^m\,13^s.0$; $\delta = -27^\circ\,10'\,13''.4$

7.9, yellow ; 14.7, purple

1897.465	164.4	6.55
.465	163.1	6.90
1897.465	163.7	6.72

Very difficult, companion extremely faint.

λ_1 194.

Cord. G.C. 18951

$\alpha = 13^h\,51^m\,27^s.5$; $\delta = -27^\circ\,1'\,57''.6$

8, yellow ; 9, yellow

1897.465	313.7	0.57
.465	314.5	0.59
1897.465	314.1	0.58

Fine system. Afterwards found by Innes.

λ_1 195.

Cord. G.C. 19032

$\alpha = 13^h\,55^m\,39^s.1$; $\delta = -31^\circ\,8'\,4''.2$

7, yellow ; 13.8, bl. purple

1897.471	237.7	22.75
.471	237.0	22.88
1897.471	237.3	22.82

λ_1 196 = θ *Centauri.*

Cord. G.C. 19129

$\alpha = 14^h\,0^m\,48^s.9$; $\delta = -35^\circ\,52'\,26''.1$

3.5, or. yellow ; 14.3, bluish

1897.373	129.1	69.85
.373	128.0	70.03
1897.373	128.6	69.94

Faint companion to bright star.

The Harvard observers at Arequipa report a companion 8^M, in 180°, 3″; I could see no trace of such an object, though I often examined θ *Centauri* under good conditions at Mexico and at Flagstaff.

λ_1 197.

Cord. Z.C. 14^h52

$\alpha = 14^h\,2^m\,10^s.4$; $\delta = -26^\circ\,52'\,6''.5$

8.8, yellow ; 8.8, yellow

1897.463	34.5	0.25
.463	37.5	0.27
1897.463	36.0	0.26

Excessively close system.

λ_1 198.

Cord. Z.C. 14^h144

$\alpha = 14^h\,3^m\,39^s.7$; $\delta = -43°\,48'\,23''.7$

8.1, yellow ; 13.1, bluish

t	θ_o	ρ_o
		″
1897.148	134.7	9.38
.148	135.3	9.41
.162	135.7	9.43
1897.153	135.2	9.41

λ_1 199.

Cord. G.C. 19205

$\alpha = 14^h\,4^m\,35^s.4$; $\delta = -29°\,36'\,54''.2$

7.4, yellow ; 13.8, bl. purple

1897.386	226.5	8.12
.386	227.5	8.38
.460	226.0	8.51
.460	224.0	8.73
1897.423	226.0	8.43

λ_1 200.

Cord. G.C. 19225

$\alpha = 14^h\,5^m\,31^s.7$; $\delta = -29°\,18'\,45''.3$

7.2, yellow ; 12.3, bl. yellow

1897.534	98.2	9.31
.534	97.3	9.23
1897.534	97.8	9.27

λ_1 201.

Cord. G.C. 19278

$\alpha = 14^h\,8^m\,2^s.7$; $\delta = -31°\,34'\,39''.9$

7.2, yellow ; 11.3, bluish.

1897.414	199.2	17.14
.414	200.0	17.64
.422	200.1	17.75
.422	200.1	17.78
1897.418	199.8	17.65

λ_1 202.

Cord. G.C. 19325

$\alpha = 14^h\,10^m\,59^s.5$; $\delta = -29°\,30'\,25''.2$

A B

7.8, yellow ; 8.4, yellow

1897.460	108.4	0.95
.460	109.7	0.86
1897.460	109.1	0.91

C, 12.5, bl. yellow.

$\frac{A\,B}{2}, C$

1897.460	134.4	30.83

Interesting triple, close pair well separated.

λ_1 203.

Cord. D.M. 29 10981

$\alpha = 14^h\,13^m\,37^s.4$; $\delta = -29°\,11'\,47''.4$

8, yellow ; 11.5, bl. purple

1897.460	94.0	10.42
.460	94.3	10.61
1897.460	94.1	10.51

λ_1 204 = ψ *Centauri.*

Cord. G.C. 19387

$\alpha = 14^h\,14^m\,28^s.6$; $\delta = -37°\,25'\,31''.0$

5, yellow ; 13.9, bluish

t	θ_o	ρ_o
		″
1897.140	87.1	34.44
.140	86.2	34.52
.159	86.1	36.52
1897.147	86.5	35.16

λ_1 205.

Cord. G.C. 19596

$\alpha = 14^h\,23^m\,26^s.8$; $\delta = -36°\,35'\,29''.7$

7.3, yellow ; 14.2, bluish

1897.373	65.2	11.07	
.373	69.0	10.82	
.447	65.8	11.13	
1897.398	66.6	11.01	
1897.447	64.6	11.38	C
.447	65.0	10.65	C
1897.447	64.8	11.01	C

λ_1 206.

Cord. G.C. 19669

$\alpha = 14^h\,26^m\,2^s.6$; $\delta = -31°\,44'\,30''.7$

A B

7, yellow ; 10.5, purple

1897.414	191.5	1.22
.414	190.2	1.00
1897.414	190.8	1.11

C, 14.5, bluish.

A C

1897.414	19.1	23.31

Important triple.

λ_1 207 = η *Centauri.*

Cord. G.C. 19737

$\alpha = 14^h\,29^m\,9^s.5$; $\delta = -41°\,43'\,5''.8$

2.6, yellow ; 14.8, purplish

1897.028	270. ±	6.0 ±
.041	264.4	5.57
.085	276.0	5.38
1897.051	270.1	5.65

A most splendid system. One of the most difficult double stars of this class known, and certain to be physically connected. A test object *par excellence* for the seeing and the telescopes of the southern hemisphere.

λ_1 208 = G 362 *Centauri.*

Cord. G.C. 19818

$\alpha = 14^h\,32^m\,19^s.3$; $\delta = -34°\,50'\,29''.3$

5.8, yellow ; 12.3, purple

1897.386	20.1	23.16
.386	20.0	23.45
1897.386	20.1	23.30

λ_1 209 = G 26 *Lupi.*

Cord. G.C. 19842

$\alpha = 14^h\,33^m\,45^s.9$; $\delta = -45°\,21'\,42''.0$

5.9, yellow ; 13.8, bluish

t	θ_o	ρ_o
	°	″
1897.230	240.3	12.73
.230	241.1	12.82
1897.230	240.7	12.78

λ_1 210.

Cord. G.C. 19895

$\alpha = 14^h\,35^m\,57^s.9$; $\delta = -32°\,23'\,8''.3$

A B

8, yellow ; 8, yellow

1897.422	264.4	0.48
.422	265.3	0.47
1897.422	264.8	0.48

C, 13.5, bl. yellow.

$\frac{A\,B}{2}, C$

1897.422	349.3	26.06

D, 13.5, bluish.

$\frac{A\,B}{2}, D$

1897.422	18.6	24.11

Splendid quadruple.

λ_1 211 *C.*

Cord. G.C. 20023

$\alpha = 14^h\,41^m\,19^s.9$; $\delta = -36°\,32'\,11''.1$

8, yellow ; 14, bluish

1897.447	178.4	14.14	C
.447	178.6	14.61	C
1897.447	178.5	14.37	C
1897.447	178.0	14.43	See

λ_1 212.

Cord. G.C. 20042

$\alpha = 14^h\,41^m\,51^s.1$; $\delta = -31°\,49'\,41''.4$

7.6, or. yellow ; 8, or. yellow

1897.395	26.4	0.26 ±
.395	31.0	0.27 ±
1897.395	28.7	0.26

Fine close double, not quite separated.

λ_1 213.

Cord. Z.C. 14^h2593

$\alpha = 14^h\,42^m\,12^s.7$; $\delta = -29°\,59'\,48''.3$

7.6, yellow ; 8.5, yellow

1897.460	167.0	0.24
.460	167.6	0.25
1897.460	167.3	0.24

Excessively close and fine double.

λ_1 214.

Cord. Z.C. 14^h2742

$\alpha = 14^h\,44^m\,47^s.9$; $\delta = -35°\,58'\,14''.8$

A B

7.6, yellow ; 13.9, bluish

t	θ_o	ρ_o
	°	″
1897.411	258.9	4.66
.411	259.7	4.56
1897.411	259.3	4.61

C, 13.5, bluish.

A C

1897.411	55.9	40.64

λ_1 215.

Cord. G.C. 20224

$\alpha = 14^h\,50^m\,21^s.4$; $\delta = -34°\,13'\,32''.8$

A B

7.4, bl. yellow ; 7.4, bl. yellow

1897.430	99.5	0.80
.430	100.5	0.73
1897.430	100.0	0.76

C, 10.2, yellow.

$\frac{A\,B}{2}$, *C*

1897.430	22.9	48.34
.430	22.8	48.33
1897.430	22.9	48.33

Independently discovered by Innes.

λ_1 216.

Cord. G.C. 20232

$\alpha = 14^h\,50^m\,43^s.6$: $\delta = -41°\,43'\,57''.3$

5.7, or. yellow ; 14, bl. purple

1897.230	78.1	16.05
.230	77.5	15.80
1897.230	77.8	15.92

λ_1 217 = G 45 *Lupi.*

Cord. G.C. 20392

$\alpha = 14^h\,56^m\,52^s.0$; $\delta = -32°\,14'\,55''.5$

4.9, yellow ; 13.7, bluish

1897.430	119.6	36.87
.430	120.2	36.68
1897.430	119.9	36.78

Very strongly suspect a faint companion 15^M in 105°, 8″.

λ_1 218 = G 46 *Lupi.*

Cord. G.C. 20407

$\alpha = 14^h\,57^m\,12^s.3$; $\delta = -35°\,33'\,0''.6$

7, yellow : 7, yellow

1897.556	12.5	0.20 ±
.556	10.1	0.18 ±
1897.556	11.3	0.19 ±

Excessively close, elongation and parallel fringes distinct.

λ_1 219 = λ *Lupi.*

Cord. G.C. 20514

$\alpha = 15^h\,2^m\,6^s.5$; $\delta = -44°\,53'\,40''.7$

4.9, yellow ; 5.6, yellow

t	θ_o	ρ_o
	°	″
1897.085	177.3	0.30 ±
.128	178.9	0.28
.128	180.5	0.31
1897.114	178.9	0.30

Fine brilliant system, separated but extremely close. An object of the highest interest.

λ_1 220.

Anon.

$\alpha = 15^h\,4^m \pm$; $\delta = -57°\,6' \pm$

6.8, yellow ; 11.3, purplish

1897.230	297.7	6.13
.230	296.6	6.42
1897.230	297.1	6.27

Place only approximate, not in the catalogues.

λ_1 221.

Cord. G.C. 20677

$\alpha = 15^h\,9^m\,31^s.1$; $\delta = -36°\,37'\,32''.2$

7.4, yellow ; 13.9, purplish

1897.367	41.1	4.82
.367	40.6	4.82
1897.367	40.8	4.82

Physical system.

λ_1 222 *C.*

Cord. Z.C. 15^h592

$\alpha = 15^h\,9^m\,58^s.2$; $\delta = -30°\,21'\,26''.5$

9, yellow ; 12.5, purple

1897.487	327.3	13.77	C
.487	326.8	13.78	C
1897.487	327.0	13.77	C
1897.487	326.6	13.47	See

λ_1 223 *C.*

Cord. Z.C. 15^h599

$\alpha = 15^h\,10^m\,3^s.7$; $\delta = -30°\,12'\,23''.6$

9, yellow ; — bl. yellow

1897.487	278.1	8.92	C
.487	278.5	8.76	C
1897.487	278.3	8.84	C

Third star n.f. 35″.

λ_1 224.

Cord. DM. 31°11848

$\alpha = 15^h\,11^m\,57^s.5$; $\delta = -31°\,41'\,24''.4$

9, yellow ; 10.5, yellow

1897.534	344.9	2.73
.534	345.2	2.82
1897.534	345.1	2.78

Faint system between two brighter stars.

λ_1 225.

Cord. Z.C. 15^h730

$\alpha = 15^h\,12^m\,9^s.3$; $\delta = -31°\,28'\,57''.3$

7.5, yellow : 12.3, yellow

t	θ_o	ρ_o
	°	″
1897.534	111.6	13.95
.534	111.1	13.84
1897.534	111.3	13.90

λ_1 226 = G 80 *Lupi.*

Cord. G.C. 20734

$\alpha = 15^h\,12^m\,33^s.6$; $\delta = -30°\,50'\,36''.4$

5.8, orange ; 14.2, bluish

1897.430	70.5	19.82
.430	71.1	20.07
.460	68.5	21.26
1897.440	70.0	20.38

λ_1 227.

Cord. DM. 30°12115

$\alpha = 15^h\,12^m\,32^s.9$; $\delta = -30°\,47'\,37''.6$

11.2, yellow ; 13.2, bl. yellow

1897.430	117.3	7.90
.430	118.3	7.52
1897.430	117.8	7.71

λ_1 228 = G 46 *Circini.*

Cord. G.C. 20775

$\alpha = 15^h\,15^m\,4^s.4$; $\delta = -60°\,17'\,48''.5$

6, yellow ; 14.1, purplish

1897.142	119.2	5.58
.142	120.0	5.53
.159	119.6	7.01
1897.148	119.6	6.04

Companion exceedingly obscure and difficult.

λ_1 229 = q_1 *Lupi.*

Cord. G.C. 20793

$\alpha = 15^h\,15^m\,27^s.7$; $\delta = -35°\,53'\,53''.4$

A B

5, reddish ; 15, purple

1897.386	241.0	16.50
.386	238.3	16.98
1897.386	239.7	16.74

C, 14.5, bluish.

A C

1897.140	119.3	17.27

Exceedingly difficult companions; *A B* resembles system of *Aldebaran.*

λ_1 230 *C.*

Cord. DM. 28°11305

$\alpha = 15^h\,15^m\,56^s.9$; $\delta = -28°\,56'\,30''.1$

9, yellow ; 9.5, yellow

1897.542	148.4	3.29	C
.542	149.3	3.17	C
1897.542	148.8	3.23	C

Nice little system.

λ_1 231 *C*.

Cord. Z.C. 15^h984

$\alpha = 15^h\ 16^m\ 6^s.1 \quad : \quad \delta = -36\ 40'\ 7''.1$

9, yellow : 14, bluish

t	θ_o	ρ_o	
		″	
1897.411	239.2	12. ±	C

Clouds. Very difficult.

λ_1 232 *C*.

Cord. Z.C. 15^h1042

$\alpha = 15^h\ 16^m\ 49^s.1 \quad : \quad \delta = -28\ 37'\ 57''.1$

7.8, or. yellow : 14.5, bluish

1897.542	50.6	8.31	C
.542	51.7	8.63	C
1897.542	51.2	8.47	C

Very difficult.

λ_1 233.

Cord. G.C. 20844

$\alpha = 15^h\ 18^m\ 2^s.5 \quad ; \quad \delta = -26^{\circ}\ 56'\ 52''.2$

7, yellow ; 14, bluish

1897.173	223.0	13.95
.173	224.4	14.20
1897.173	223.7	14.07

λ_1 234 = G 101 *Lupi*.

Cord. G.C. 20910

$\alpha = 15^h\ 21^m\ 9^s.4 \quad ; \quad \delta = -51\ 14'\ 56''.4$

6, orange ; 12, bl. purple

1897.170	31.4	13.98

λ_1 235.

Cord. Z.C. 15^h1431

$\alpha = 15^h\ 22^m\ 32^s.0 \quad ; \quad \delta = -33^{\circ}\ 58'\ 54''.1$

8, yellow : 12.5, bluish

1897.548	260.8	5.27
.548	259.6	5.45
1897.548	260.2	5.36

λ_1 236.

Anon., near Cord. G.C. 20959

$\alpha = 15^h\ 22^m\ 49^s.3 \quad : \quad \delta = -38^{\circ}\ 17'\ 10''.0$

8.3, yellow : 8.7, yellow

1897.131	247.9	1.77
.134	246.3	1.50
.164	246.7	1.21
1897.144	247.0	1.49

The place is that of Cord. G.C. 20959. The system is s.p.

λ_1 237.

Cord. Z.C. 15^h1474

$\alpha = 15^h\ 23^m\ 5^s.1 \quad ; \quad \delta = -35^{\circ}\ 3'\ 20''.4$

8, yellow ; 12.3, purplish

1897.479	286.8	9.76
.479	287.5	9.88
.518	287.1	9.46
.518	287.8	9.19
1897.498	287.3	9.65

λ_1 238 = G 86 *Librae*.

Cord. G.C. 21062

$\alpha = 15^h\ 27^m\ 13^s.8 \quad ; \quad \delta = -24\ 8'\ 58''.0$

AB

7.1, yellow : 7.1, yellow

t	θ_o	ρ_o
		″
1897.504	138.0	0.16
.504	137.6	0.24
1897.504	137.8	0.20

C, 6, yellow.

$\frac{AB}{2}$, C = South 673

1897.504	119.0	9.34
.504	119.3	9.13
1897.504	119.1	9.23

A splendid triple. The wide pair was discovered by Sir JAMES SOUTH in 1824, and is relatively fixed, or has common proper motion. The close pair is likely to have rapid orbital motion and will deserve regular attention. This new object was so well divided under the steady atmosphere of Arizona that I showed it to visitors on several occasions in July.

λ_1 239.

Cord. G.C. 21060

$\alpha = 15^h\ 27^m\ 24^s.9 \quad : \quad \delta = -46^{\circ}\ 53'\ 32''.1$

7.5, yellow : 12.5, bluish

1897.192	6.7	13.64

λ_1 240 *C*.

Anon

$\alpha = 15^h\ 28^m\ 35^s.\pm \quad : \quad \delta = -46^{\circ}\ 43'\pm$

8.5, yellow ; 13.5, purple

1897.178	285.1	16.08	C
1897.227	283.8	17.13	See

Companion difficult.

λ_1 241.

Cord. DM. $23^{\circ}12411$

$\alpha = 15^h\ 30^m\ 54^s.6 \quad ; \quad \delta = -23\ 20'\ 52''.7$

7, yellow ; 10.5, purple

1897.502	27.4	0.95
.502	27.3	0.99
1897.502	27.3	0.97

Nice system.

λ_1 242.

Cord. G.C. 21164

$\alpha = 15^h\ 31^m\ 39^s.6 \quad ; \quad \delta = -30^{\circ}\ 55'\ 18''.9$

7, yellow ; 9.5, bl. purple

1897.425	5.0	0.67
.425	6.4	0.52
1897.425	5.7	0.59

Fine system.

λ_1 243.

Cord. Z.C. 15^h2214

$\alpha = 15^h\ 33^m\ 44^s.4 \quad : \quad \delta = -31^{\circ}\ 3'\ 35''.5$

8, yellow : 10.3, bl. yellow

t	θ_o	ρ_o	
	°	″	
1897.425	26.6	1.07	
.425	27.3	1.11	
1897.425	27.0	1.09	See
1897.540	27.0	1 12	C
.540	27.6	1.05	C
1897.540	27.3	1.08	C

Afterwards found by INNES.

λ_1 244.

Cord. G.C. 21250

$\alpha = 15^h\ 35^m\ 30^s.1 \quad ; \quad \delta = -31^{\circ}\ 31'\ 28''.4$

8, yellow ; 9, yellow

1897.425	29.3	0.89
.425	29.3	0.89
1897.425	29.3	0.89

Fine close system.

λ_1 245.

Cord. Z.C. 15^h2441

$\alpha = 15^h\ 36^m\ 34^s.8 \quad ; \quad \delta = -34^{\circ}\ 22'\ 32''.7$

9.2, yellow : 9.4, yellow

1897.151	168.8	0.34
.151	169.4	0.37
.164	165.9	0.34
1897.156	168.0	0.35

Fine little system, just well separated.

λ_1 246.

Cord. G.C. 21291

$\alpha = 15^h\ 36^m\ 59^s.0 \quad : \quad \delta = -27^{\circ}\ 39'\ 24''.0$

8, or. yellow : 14, bluish

1897.485	310.4	14.16
.485	309.7	13.67
1897.485	310.1	13.91

The n.p. star of a wide double.

λ_1 247.

Cord. G.C. 21294

$\alpha = 15^h\ 37^m\ 13^s.0 \quad ; \quad \delta = -39\ 7'\ 31''.0$

7.9, yellow ; 14.5, purplish

1897.383	277.8	13.50
.383	278.4	13.01
1897.383	278.6	13.25

Very difficult.

λ_1 248.

Cord. G.C. 21329

$\alpha = 15^h\ 38^m\ 42^s.4 \quad ; \quad \delta = -34\ 47'\ 8''.9$

8, yellow ; 8, yellow

1897.479	190. ±	0.20 ±

Excessively close pair.

λ_1 249 = G 131 *Lupi.*

Cord. G.C. 21374

$\alpha = 15^h\,41^m\,0^s.3$; $\delta = -37^\circ\,35'\,54''.1$

A B

5.8, or. yellow ; 14, purple

t	θ_o	ρ_o
	°	″
1897.373	129.9	14.77
.373	131.8	14.83
.556	128.3	15.54
.556	130.8	15.55
1897.464	130.2	15.17

Very difficult. *C*, 14.6, bluish.

A C Harvard.

1897.373	225.6	25.36
.373	227.0	25.28
.556	225.6	24.31
1897.434	226.1	24.98

λ_1 250.

Cord. Z.C. 15h3019

$\alpha = 15^h\,44^m\,40^s.3$; $\delta = -34^\circ\,44'\,35''.3$

8.2, yellow ; 8.8, yellow

1897.479	100.5	0.58
.479	100.9	0.54
1897.479	100.7	0.56

Fine system, nicely separated.

λ_1 251 = ρ *Scorpii.*

Cord. G.C. 21592

$\alpha = 15^h\,50^m\,42^s.6$; $\delta = -28^\circ\,55'\,19''.1$

3.2, bl. yellow : 13.7, bluish

1897.485	98.6	38.10
.485	98.0	38.71
1897.485	98.3	38.41

Faint companion to bright star.

λ_1 252.

Cord. Z.C. 15h3468

$\alpha = 15^h\,51^m\,3^s.6$; $\delta = -40^\circ\,42'\,24''.6$

A B

8.5, yellow ; 8.5, yellow

1897.211	281.8	0.37 est. 0″.35
.211	281.1	0.38
1897.211	281.4	0.37

Excessively close. *C*, 13, bl. yellow.

$\frac{AB}{2}, C$

1897.211	214.5	18.43
.211	214.9	18.44
1897.211	214.7	18.43

Physical triple of high interest.

λ_1 253.

Cord. G.C. 21649

$\alpha = 15^h\,53^m\,17^s.0$; $\delta = -35^\circ\,33'\,26''.3$

8, yellow ; 12.3, purple

1897.386	126.0	13.34
.386	126.2	13.95
1897.386	126.1	13.64

λ_1 254.

Cord. G.C. 21671

$\alpha = 15^h\,54^m\,2^s.3$; $\delta = -46^\circ\,15'\,12''.0$

7, yellow ; 11.3, yellow

t	θ_o	ρ_o
	°	″
1897.192	193.6	1.10
.192	193.8	1.12
1897.192	193.7	1.11

Close and important system.

λ_1 255 *C.*

Cord. G.C. 21680

$\alpha = 15^h\,54^m\,8^s.0$; $\delta = -25^\circ\,53'\,31''.1$

A B

7.2, yellow : 9.2, yellow

1897.540	342.4	15.84	C
.540	342.4	15.70	C
1897.540	342.4	15.77	C

C, 14, bluish.

A C

1897.540	21.1	11.95	C
.540	20.3	—	C
1897.540	20.7	11.95	C

A triple, making almost an equilateral triangle.

λ_1 256.

Cord. Z.C. 15h3712

$\alpha = 15^h\,54^m\,24^s.3$; $\delta = -35^\circ\,42'\,35''.8$

7.8, yellow ; 12, bl. yellow

1897.556	127.0	13.80
.556	127.7	13.31
1897.556	127.3	13.56

λ_1 257 *C.*

Cord. Z.C. 15h3750

$\alpha = 15^h\,55^m\,2^s.2$; $\delta = -28^\circ\,3'\,0''.9$

7.2, yellow ; 12, bl. yellow

1897.542	338.3	6.79	C
.542	339.1	6.86	C
1897.542	338.7	6.82	C

λ_1 258 = ι_1 *Normae.*

Cord. G.C. 21694

$\alpha = 15^h\,55^m\,24^s.3$; $\delta = -57^\circ\,29'\,33''.7$

A B

6.6, or. yellow ; 6.8, or. yellow

1897.137	265.2	0.97
.137	265.3	0.91
.159	267.7	0.65
1897.145	266.1	0.84

C, 11.1, purple.

$\frac{AB}{2}, C - h\,4825$

1897.137	249.7	10.98
.137	251.6	11.00
.159	247.4	10.86
1897.145	249.6	10.95

Splendid triple of highest interest.
The HERSCHEL component *C* is almost fixed.

λ_1 259.

Cord. G.C. 21706

$\alpha = 15^h\,55^m\,32^s.1$: $\delta = -36^\circ\,27'\,43''.6$

7.2, yellow ; 7.3, yellow

t	θ_o	ρ_o
	°	″
1897.427	18.0	0.20 ±
.427	17.4	0.20 ±
1897.427	17.7	0.20 ±

Excessively close system.

λ_1 260 *C.*

Cord. Z.C. 15h3786

$\alpha = 15^h\,55^m\,33^s.0$; $\delta = -28^\circ\,10'\,36''.0$

7.9, yellow ; 9, yellow

1897.542	21.4	6.73	C
.542	21.7	6.67	C
1897.542	21.5	6.70	C

λ_1 261 *C.*

Cord. Z.C. 15h3794

$\alpha = 15^h\,55^m\,38^s.6$; $\delta = -28^\circ\,1'\,26''.8$

8, or. yellow ; 14, bluish

1897.542	14.8	10.86	C
.542	14.4	10.60	C
1897.542	14.6	10.73	C

Difficult.

λ_1 262.

Cord. Z.C. 15h3957

$\alpha = 15^h\,58^m\,2^s.7$; $\delta = -40^\circ\,7'\,36''.5$

8.2, yellow ; 8.7, yellow

1897.559	328.7	1.15
.559	328.9	0.88
1897.559	328.8	1.01

λ_1 263.

Cord. G.C. 21775

$\alpha = 15^h\,58^m\,19^s.7$; $\delta = -38^\circ\,56'\,26''.2$

6.6, yellow ; 13.9, purple

1897.419	213.8	9.19
.419	213.8	9.18
1897.419	213.8	9.19

λ_1 264.

Cord. G.C. 21794

$\alpha = 15^h\,59^m\,20^s.6$; $\delta = -32^\circ\,34'\,55''.2$

A B

7.6, yellow ; 9.1, yellow

1897.479	339.9	0.53
.479	340.1	0.57
1897.479	340.0	0.55

C, 12.7, bl. purple.

A C

1897.479	9.7	9.99
.479	9.9	9.93
1897.479	9.8	9.96

Most interesting triple.

λ_1 265 = G 23 *Scorpii.*

Cord. G.C. 21854

$\alpha = 16^h\,1^m\,52^s.6$: $\delta = -38^\circ\,49'\,27''.7$

5.8, yellow : 13.6, purple

t	θ_0	ρ_0
	°	″
1897.419	297.8	16.32
.419	297.3	16.41
1897.419	297.6	16.37

λ_1 266.

Cord. G.C. 21885

$\alpha = 16^h\,3^m\,29^s.1$: $\delta = -35^\circ\,22'\,33''.6$

7.8, yellow ; 9, yellow

1897.386	205. ±	0.20 ±
.386	208. ±	0.20 ±
1897.386	206.5 ±	0.20 ±

Excessively close and very important system. Not quite separated with 1500.

λ_1 267.

Cord. G.C. 21923

$\alpha = 16^h\,5^m\,22^s.2$; $\delta = -42^\circ\,6'\,52''.6$

8, yellow ; 14.2, bl. purple

1897.625	188.3	4.96
.625	190.2	4.89
1897.625	189.2	4.92

Very difficult; third star preceding by 49″.±

λ_1 268.

Cord. G.C. 21980

$\alpha = 16^h\,7^m\,59^s.9$; $\delta = -38^\circ\,52'\,33''.7$

7.4, yellow ; 7.5, yellow

1897.416	165.0	2.26
.416	165.1	2.14
.419	163.5	2.07
.419	164.5	2.23
1897.417	164.5	2.17

Interesting system.

λ_1 269 = G 45 *Normae.*

Cord. G.C. 22013

$\alpha = 16^h\,9^m\,36^s.1$: $\delta = -52^\circ\,50'\,5''.7$

A B

6.5, yellow ; 6.5, yellow

1897.230	213.4	0.20 ±
.230	213.1	0.20 ±
1897.230	213.4	0.20 ±

C, 14. bluish.

$\frac{AB}{2}, C$

1897.230	5.4	21.32
.230	4.6	20.83
1897.230	5.0	21.07

Fine brilliant triple.

λ_1 270 *C.*

Cord. G.C. 22044

$\alpha = 16^h\,10^m\,37^s.1$: $\delta = -29^\circ\,29'\,38''.7$

7, yellow ; 13.7, bluish

t	θ_0	ρ_0	
	°	″	
1897.534	138.0	8.08	C
.534	139.3	8.55	C
1897.531	138.6	8.31	C

Difficult.

λ_1 271 = λ *Normae.*

Cord. G.C. 22082

$\alpha = 16^h\,12^m\,20^s.0$: $\delta = -42^\circ\,25'\,44''.5$

5.2, yellow ; 6, yellow

1897.131	150.9	0.31
.211	153.2	0.39
1897.172	152.0	0.35

Close system of great interest.

λ_1 272 = G 54 *Scorpii.*

Cord. G.C. 22097

$\alpha = 16^h\,12^m\,45^s.0$: $\delta = -35^\circ\,14'\,44''.4$

6.6, yellow ; 6.6, yellow

1897.383	284.5	0.25 ±
.383	280.5	0.25 ±
.430	279.0	0.28
.430	280.5	0.25
.556	280.4	0.33
.556	280.8	0.33
1897.456	280.2	0.30

Splendid system, just barely divided.

λ_1 273 = G 56 *Scorpii.*

Cord. G.C. 22115

$\alpha = 16^h\,13^m\,27^s.7$: $\delta = -39^\circ\,23'\,16''.9$

7.8, yellow ; 7.8, yellow

1897.416	175. ±	0.40 ±
.416	176. ±	0.30 ±
1897.416	175.5	0.35

A fine close system.

λ_1 274.

Cord. Z.C. 16^h1157

$\alpha = 16^h\,18^m\,13^s.1$; $\delta = -40^\circ\,24'\,41''.4$

A B

8, yellow ; 13, bl. purple

1897.419	243.2	5.38
.559	240.9	4.47
.559	241.5	4.40
1897.512	241.9	4.75

C, 14, bluish.

A C

1897.559	294.3	12.94

D, 13, yellow.

A D

1897.419	251.6	26.93

A quadruple in the center of a cluster.

λ_1 275.

Cord. Z.C. 16^h1227

$\alpha = 16^h\,19^m\,8^s.5$; $\delta = -40^\circ\,37'\,14''.5$

8.3, yellow ; 14.2, bluish

t	θ_0	ρ_0
	°	″
1897.559	181.3	12.32
.559	180.7	12.17
1897.559	181.0	12.24

Very difficult system; the southern star of a small figure resembling the southern cross.

λ_1 276.

Cord. G.C. 22235

$\alpha = 16^h\,19^m\,17^s.5$; $\delta = -33^\circ\,20'\,11''.8$

7, yellow : 14.1, bluish

1897.556	150.4	15.16
.556	152.3	15.08
1897.556	151.3	15.12

λ_1 277.

Cord. G.C. 22241

$\alpha = 16^h\,19^m\,31^s.1$; $\delta = -29^\circ\,41'\,29''.9$

8, yellow ; 9.1, yellow

1897.468	202.3	0.39
.468	202.9	0.43
.657	201.8	0.46
.657	203.0	0.38
1897.562	202.5	0.42

Fine close system, barely separated.

λ_1 278 *C.*

Cord. G.C. 22249

$\alpha = 16^h\,19^m\,39^s.8$; $\delta = -31^\circ\,0'\,12''.5$

8.8, yellow : 8.8, yellow

1897.542	317.6	0.68	C
.542	317.5	0.59	C
1897.512	317.5	0.63	C

λ_1 279.

Cord. G.C. 22275

$\alpha = 16^h\,21^m\,36^s.8$; $\delta = -51^\circ\,19'\,10''.8$

7.5, yellow : 12.8, bl. yellow

1897.230	339.7	9.56

λ_1 280 *C.*

Cord. Z.C. 16^h1875

$\alpha = 16^h\,28^m\,54^s.3$; $\delta = -36^\circ\,54'\,3''.4$

8, yellow : 14.2, purple

1897.548	249.1	8.08	C
.548	249.1	8.46	C
1897.548	249.1	8.27	C

Difficult.

λ_1 281.

Cord. Z.C. 16^h1997

$\alpha = 16^h\,30^m\,25^s.1$; $\delta = -33^\circ\,50'\,58''.4$

A B

8.2, bluish ; 13.3, bluish

t	θ_o	ρ_o
	°	″
1897.479	256.3	9.28
.479	254.6	8.97
1897.479	255.4	9.12

C, 14.8, bluish.

A C

1897.479	244.2	18.37

λ_1 282.

Cord. G.C. 22515

$\alpha = 16^h\,32^m\,59^s.0$; $\delta = -34^\circ\,0'\,25''.1$

8.5, yellow ; 12.8, bl. yellow

1897.655	205.3	2.42
.655	204.6	2.56
1897.655	205.0	2.49

λ_1 283.

Cord. G.C. 22529

$\alpha = 16^h\,33^m\,31^s.9$; $\delta = -39^\circ\,43'\,26''.2$

A B

7, yellow ; 13.3, purple

1897.627	183.3	11.64
.627	183.6	11.60
1897.627	183.4	11.62

C, 10, purple.

A C

1897.627	268.9	25.20

λ_1 284 = G 80 *Scorpii.*

Cord. G.C. 22583

$\alpha = 16^h\,35^m\,47^s.6$; $\delta = -36^\circ\,53'\,1''.4$

6.4, orange ; 7.5, purplish

1896.608	90.2	1.03(1)
.627	92.3	0.78
.638	100.6	0.90
1896.624	94.4	0.90

(1) Shown to Mr. ALVAN G. CLARK.

1897.373	86.4	1.12
.425	85.0	0.97
1897.399	85.7	1.04
1897.540	87.0	0.93 C

Beautiful double, independently discovered by INNES.

λ_1 285.

Cord. Z.C. 16^h2556

$\alpha = 16^h\,38^m\,7^s.5$; $\delta = -27^\circ\,14'\,51''.1$

8.3, yellow ; 13.1, bluish

1897.485	259.4	14.37
.485	259.4	14.67
1897.485	259.4	14.42

λ_1 286.

Cord. G.C. 22633

$\alpha = 16^h\,38^m\,37^s.5$; $\delta = -27^\circ\,16'\,8''.8$

8, yellow ; 11.5, bl. yellow

t	θ_o	ρ_o
	°	″
1897.485	30.5	11.28
.485	30.5	11.40
1897.485	30.5	11.34

λ_1 287.

Anon., near Cord. G.C. 22663

$\alpha = 16^h\,39^m\,56^s.5$; $\delta = -39^\circ\,22'\,31''.3$

10.2 yellow, ; 11.2, bl. yellow

1897.416	54.1	11.02
.416	54.2	10.81
1897.416	54.2	10.91

λ_1 288 = G 94 *Scorpii.*

Cord. G.C. 22714

$\alpha = 16^h\,42^m\,46^s.7$; $\delta = -33^\circ\,50'\,17''.9$

A B

6.2, yellow ; 13.3, bl. yellow

1897.425	133.9	19.13
.425	135.4	19.59
.518	136.8	19.39
.518	136.8	19.14
1897.472	135.7	19.31

C, 13.4, bl. yellow.

A C

1897.518	162.2	20.13
.518	162.8	19.95
1897.518	162.5	20.04

λ_1 289.

Cord. G.C. 22747

$\alpha = 16^h\,44^m\,14^s.4$; $\delta = -31^\circ\,27'\,46''.0$

7, orange ; 15, dingy

1897.463	99.6	3.37
.463	99.4	3.49
1897.463	99.5	3.43

Companion extremely difficult, shining with a singular dull luster. Very remarkable system.

λ_1 290.

Cord. Z.C. 16^h3065

$\alpha = 16^h\,45^m\,21^s.5$; $\delta = -35^\circ\,17'\,18''.1$

7.8, or. yellow ; 13.2, bl. purple

1897.386	72.4	10.35
.386	72.6	10.51
1897.386	72.5	10.43

λ_1 291.

Cord. G.C. 22794

$\alpha = 16^h\,46^m\,7^s.8$; $\delta = -25^\circ\,25'\,51''.2$

7.6, yellow ; 13.9, bl. purple

t	θ_o	ρ_o
	°	″
1897.655	7.0	2.69
.655	6.8	2.60
1897.655	6.9	2.64

Exceedingly difficult.

λ_1 292 = ζ_1 *Scorpii.*

Cord. G.C. 22812

$\alpha = 16^h\,46^m\,56^s.4$; $\delta = -42^\circ\,11'\,43''.8$

5, yellow ; 5.7, yellow

1896.698	190. ±	0.25 ±
.701	190. ±	0.25 ±
1897.148	175.0	0.20
1896.849	185.0	0.23

Excessively close, fine system.

λ_1 293 = G 101 *Scorpii.*

Cord. G.C. 22814

$\alpha = 16^h\,47^m\,0^s.9$; $\delta = -41^\circ\,38'\,23''.4$

$\frac{A\,B}{2}, C$

6.3, or. yellow ; 14.7, bluish

1897.493	131.2	18.49
.502	125.9	18.01(1)
1897.497	128.5	18.25

(1) Very difficult, a tree obstructing the vision.

D, 14, bluish.

$\frac{A\,B}{2}, D$

1897.493	282.1	20.85
.493	282.5	20.96
.502	282.7	20.88(1)
1897.496	282.4	20.90

(1) Large star examined under various powers; double in 270°, 0″.2; perfectly sure.

A B

7, orange ; 7, orange

1897.502	270. ±	0.2 ±

Splendid quadruple of high interest.

λ_1 294.

Cord. G.C. 22817

$\alpha = 16^h\,47^m\,2^s.7$; $\delta = -41^\circ\,37'\,32''.2$

A B

7.1, or. yellow ; 14.7, purplish

1897.502	51.1	6.41

C, 10.6, purple.

A C = *h* 4892

1897.381	301.5	9.28
.381	300.8	9.06
.502	300.7	8.80
1897.422	301.0	9.05

B is very difficult.

λ_1 295.

Anon.

$\alpha = 16^h\,47^m\,5^s.5$; $\delta = -41°\,41'\,7''.6$

10.2, yellow ; 12.2, bl. yellow

t	θ_o	ρ_o
	°	″
1897.381	11.3	4.84
.381	13.2	4.78
.502	13.6	6.03
1897.421	12.7	5.22

λ_1 296.

Cord. G.C. 22818

$\alpha = 16^h\,47^m\,5^s.8$; $\delta = -41°\,34'\,27''.0$

6.9, yellow ; 13.8, bl. yellow

1897.503	242.1	20.00

λ_1 297.

Cord. G.C. 22822

$\alpha = 16^h\,47^m\,8^s.9$; $\delta = -41°\,39'\,22''.5$

A B

7, or. yellow ; 13, purple

1897.381	128.5	13.47
.381	128.8	13.31
1897.381	128.6	13.39

C, 13.1, purple.

A C

1897.381	119.5	24.01

λ_1 298.

Anon.

$\alpha = 16^h\,47^m\,10^s.8$; $\delta = -41°\,35'\,47''.6$

A B

9, yellow ; 10, yellow

1897.383	323.6	18.28
.383	323.6	18.64
1897.383	323.6	18.46

C, 13.5, bl. yellow.

B C

1897.383	282.0	5.98
.383	281.6	6.14
1897.383	281.8	6.06

λ_1 299.

Anon.

$\alpha = 16^h\,47^m\,12^s.3$; $\delta = -41°\,36'\,1''.8$

A B

9.5, yellow ; 12, bl. yellow

1897.502	281.1	6.53

C, 11, yellowish.

A C

1897.502	144.8	17.66

λ_1 300.

Anon.

$\alpha = 16^h\,47^m\,13^s.5$; $\delta = -41°\,40'\,10''.0$

10, yellow ; 14.1, bluish

t	θ_o	ρ_o
	°	″
1897.383	267.6	7.56
.383	267.0	7.21
.502	265.7	7.46
1897.423	266.1	7.41

λ_1 301.

Cord. Z.C. 16^h3223

$\alpha = 16^h\,47^m\,24^s.8$; $\delta = -41°\,40'\,0''.9$

7.6, yellow ; 11.5, purple

1897.381	51.0	7.61
.381	50.8	8.22
.502	51.7	7.61
1897.421	51.2	7.81

λ_1 302.

Anon.

$\alpha = 16^h\,47^m\,28^s.5$; $\delta = -41°\,43'\,2''.1$

12, bl. yellow ; 13, bl. yellow

1897.383	37.3	1.62
.383	36.1	1.56
1897.383	36.7	1.59

λ_1 303.

Cord. G.C. 22845

$\alpha = 16^h\,48^m\,1^s.0$; $\delta = -41°\,55'\,35''.9$

7, or. yellow ; 12.2, purple

1897.373	164.2	21.96
.373	162.9	21.70
1897.373	163.5	21.83

λ_1 304.

Cord. G.C. 22847.

$\alpha = 16^h\,48^m\,2^s.1$; $\delta = -40°\,24'\,59''.2$

7.3, or. yellow ; 13.8, bl. purple

1897.373	244.9	19.04
.373	245.0	18.60
1897.373	245.0	18.82

λ_1 305.

Anon.

$\alpha = 16^h\,48^m\,31^s.4$; $\delta = -39°\,21'\,18''.3$

9.9, yellow ; 13.3, bl. yellow

1897.463	328.9	7.96
.463	328.6	7.87
1897.463	328.8	7.91

λ_1 306.

Cord. G.C. 22865

$\alpha = 16^h\,48^m\,32^s.7$; $\delta = -39°\,19'\,16''.4$

7, yellow ; 13, purplish

1897.463	350.2	15.31
.463	350.1	15.49
1897.463	350.1	15.40

λ_1 307.

Anon.

$\alpha = 16^h\,48^m\,32^s.9$; $\delta = -39°\,17'\,23''.2$

9.5, yellow ; 12.7, bl. yellow

t	θ_o	ρ_o
	°	″
1897.463	93.0	7.52
.463	93.3	7.55
1897.463	93.1	7.53

λ_1 308.

Cord. Z.C. 16^h3331

$\alpha = 16^h\,48^m\,38^s.8$; $\delta = -39°\,18'\,22''.6$

9, yellow ; 13.7, bluish

1897.463	178.2	4.43
.463	179.7	4.62
1897.463	179.0	4.52

λ_1 309.

Anon.

$\alpha = 16^h\,48^m\,45^s.4$; $\delta = -39°\,18'\,13''.5$

7.8, yellow ; 14.3, bluish

1897.463	152.8	9.60
.463	151.6	9.34
1897.463	152.2	9.47

Very difficult.

λ_1 310 = G 108 *Scorpii.*

Cord. G.C. 22870

$\alpha = 16^h\,48^m\,45^s.4$; $\delta = -39°\,20'\,32''.8$

7, orange ; 13.8, bluish

1897.463	125.7	12.64
.463	125.5	12.04
1897.463	125.6	12.34

λ_1 311 = G 111 *Scorpii.*

Cord. G.C. 22915

$\alpha = 16^h\,49^m\,52^s.5$; $\delta = -31°\,8'\,43''.8$

7.5, yellow ; 14.9, dingy

1897.468	128.7	3.31
.468	129.1	3.19
1897.468	128.9	3.25

Companion excessively difficult, shining with a dull luster.

λ_1 312.

Cord. Z.C. 16^h3438

$\alpha = 16^h\,49^m\,54^s.8$; $\delta = -31°\,13'\,14''.2$

8.8, orange yellow ; 13.5, purple

1897.468	353.0	9.17
.468	353.1	9.43
1897.468	353.0	9.30

λ_1 313.

Cord. G.C. 22920

$\alpha = 16^h\,50^m\,10^s.9$; $\delta = -38°\,16'\,24''.8$

8, yellow ; 9.8, bl. purple

1897.627	233.1	2.48
.627	232.5	2.53
1897.627	232.8	2.50

λ_1 314.

Cord. G.C. 22927

$\alpha = 16^h\,50^m\,29^s.7$; $\delta = -32^\circ\,10'\,36''.7$

A B

6.3, orange ; 14.5, bluish

t	θ_o	ρ_o
	°	″
1897.430	20.8	14.36
.430	21.8	14.54
1897.430	21.3	14.45

C, 15, bluish.

B C

1897.430	330.7	6.35

λ_1 315 = G 114 *Scorpii.*

Cord. G.C. 22962

$\alpha = 16^h\,52^m\,6^s.2$; $\delta = -37^\circ\,27'\,50''.4$

7.2, yellow ; 7.2, yellow

1897.518	203.7	0.31
.518	203.0	0.31
1897.518	203.4	0.31

Very fine close system.

λ_1 316 = G 29 *Arae.*

Cord. G.C. 22980

$\alpha = 16^h\,52^m\,54^s.2$; $\delta = -48^\circ\,29'\,33''.8$

7.4, yellow ; 8.1, yellow

1897.145	177.7	0.40
.164	179.3	0.69
.164	179.9	0.68
1897.158	178.9	0.59

Fine system.

λ_1 317.

Cord. Z.C. 16^h3807

$\alpha = 16^h\,55^m\,39^s.2$; $\delta = -29^\circ\,31'\,31''.5$

8, orange ; 13.5, bl. purple

1897.638	356.2	9.78
.638	357.0	9.47
1897.638	356.6	9.62

Third star in line, 35″.

λ_1 318.

Cord. Z.C. 16^h4113

$\alpha = 16^h\,59^m\,20^s.6$; $\delta = -38^\circ\,29'\,29''.5$

8, yellow ; 8.5, yellow

1897.627	234.6	0 29 est. 0″.3
.627	236.0	0.30
1897.627	235.3	0.29

Excessively close, fine system.

λ_1 319.

Cord. Z.C. 17^h64

$\alpha = 17^h\,2^m\,23^s.9$; $\delta = -26^\circ\,42'\,19''.2$

8.2, yellow ; 13.1, purple

1897.649	207.5	7.49
.649	208.8	7.25
1897.649	208.1	7.37

λ_1 320 = G 127 *Scorpii.*

Cord. G.C. 23257

$\alpha = 17^h\,5^m\,21^s.8$; $\delta = -39^\circ\,22'\,51''.8$

7.7, yellow ; 8.3, yellow

t	θ_o	ρ_o
	°	″
1897.668	297.1	0.62
.668	293.8	0.55
.671	291.0	0.70
1897.669	294.0	0.62

Close, but well separated.

λ_1 321 = G 131 *Scorpii.*

Cord. G.C. 23306

$\alpha = 17^h\,7^m\,31^s.8$; $\delta = -39^\circ\,38'\,53''.0$

A B

7.5, reddish ; 7.8, reddish

1896.671	90. ±	0.50 ±
.681	104.5	0.52
.692	101.6	0.60
.692	102.3	0.71
1896.689	102.8	0.61

Distance est. 0″.35; measured distances probably too large.

C, 10, purple.

$\frac{A\ B}{2}$, $C = h\,4926$

1896.692	331.8	15.65

D, 11, purple.

$\frac{A\ B}{2}$, D

1896.692	206.7	17.65

Interesting quadruple.

λ_1 322 = G 135 *Scorpii.*

Cord. G.C. 23352

$\alpha = 17^h\,9^m\,16^s.4$; $\delta = -33^\circ\,37'\,20''.3$

7.5, yellow ; 7.6, yellow

1897.430	0.5	0.21
.430	2.0	0.19
1897.430	1.3	0.20

Excessively close, fine system.

λ_1 323.

Cord. G.C. 23353

$\alpha = 17^h\,9^m\,20^s.5$; $\delta = -38^\circ\,13'\,21''.1$

7.6, yellow ; 7.9, yellow

1897.518	185.0	0.21
.518	183.7	0.19
1897.518	184.3	0.20

Fine close system.

λ_1 324.

Cord. G.C. 23396

$\alpha = 17^h\,11^m\,15^s.4$; $\delta = -38^\circ\,3'\,13''.4$

7.5, yellow ; 7.5, yellow

1897.717	36.3	0.25 est. 0″.18
.717	34.1	0.29
1897.717	35.2	0.27

Close and difficult.

λ_1 325.

Cord. G.C. 23494

$\alpha = 17^h\,15^m\,44^s.4$; $\delta = -30^\circ\,24'\,6''.0$

8, or. yellow ; 10.5, or. yellow

t	θ_o	ρ_o
	°	″
1897.502	233.1	4.35
.502	232.5	4.13
1897.502	232.8	4.24

λ_1 326.

O.A. 16672

$\alpha = 17^h\,16^m\,5^s.4$; $\delta = -20^\circ\,38'\,31''.8$

8.4, yellow ; 8.9, yellow

1897.649	13.3	0.57 est. 0″.5
.649	14.2	0.61
1897.649	13.7	0.59

Just well separated.

λ_1 327 = G 145 *Scorpii.*

Cord. G.C. 23505

$\alpha = 17^h\,16^m\,7^s.4$; $\delta = -37^\circ\,7'\,18''.9$

5.5, orange ; 14.4, bluish

1897.463	221.8	20.13
.463	221.6	20.18
1897.463	221.7	20.15

λ_1 328 *C.*

Anon. near Cord. G.C. 23584

$\alpha = 17^h\,19^m\,24^s.7$; $\delta = -50^\circ\,32'\,28''.4$

11.5, bluish ; 12.5, bluish

1897.170	274.5	2.64	C

Interesting faint system. Place of Cord. G.C. 23584.

λ_1 329 *C.*

Cord. G.C. 23671

$\alpha = 17^h\,22^m\,47^s.5$; $\delta = -23^\circ\,21'\,29''.1$

8, yellow ; 12, purple

1897.673	112.0	3.39	C
.673	112.5	3.46	C
1897.673	112.2	3.42	C

λ_1 330.

Cord. Z.C. 17^h1504

$\alpha = 17^h\,23^m\,47^s.5$; $\delta = -30^\circ\,10'\,40''.6$

8.1, or. yellow ; 9.7, or. yellow

1897.502	169.3	1.68
.502	168.9	1.56
1897.502	169.1	1.62

λ_1 331.

Cord. G.C. 23695

$\alpha = 17^h\,24^m\,5^s.9$; $\delta = -48^\circ\,40'\,26''.5$

7, yellow ; 8.2, yellow

1897.192	193.5	0.68
.211	194.1	0.73
1897.201	193.8	0.70

Close system of high interest.

λ_1 332.

Cord. Z.C. 17^h1542

$\alpha = 17^h\,24^m\,18^s.5$; $\delta = -27°\,7'\,26''.7$

A B

7.5, yellow ; 11.8, purple

t	θ_o	ρ_o
	°	″
1897.706	188.9	7.83
.706	188.4	7.74
1897.706	188.7	7.78

C, 13, purple.

A C

1897.706	356.6	16.85

λ_1 333 *C*.

Cord. G.C. 23766

$\alpha = 17^h\,26^m\,36^s.8$; $\delta = -44°\,0'\,16''.4$

7, yellow ; 13, bluish

1897.463	286.8	13.85	C

λ_1 334 = λ *Scorpii.*

Cord. G.C. 23778

$\alpha = 17^h\,26^m\,49^s.0$; $\delta = -37°\,1'\,50''.6$

A B

2, bl. yellow ; 14.9, bluish

1897.625	109.4	42.05
.625	109.4	41.42
1897.625	109.4	41.73

C, 12, bl. yellow.

A C = Δ218

1897.419	331.0	94.88

B is very difficult; the system *A B* is similar to that of *Fomalhaut*.

λ_1 335 = θ *Scorpii.*

Cord. G.C. 23849

$\alpha = 17^h\,30^m\,7^s.9$; $\delta = -42°\,56'\,2''.1$

2, reddish ; 14, greenish

1896.695	320. ±	6.02
.698	320.6	5.00
.701	323.6	7.20
.703	322.3	6.80
.706	320.2	5.24
.709	322.6	7.16
1896.702	321.5	6.24
1897.192	313.3	6.80
.701	318.5	6.74
1897.446	316.9	6.77

Magnificent system of surpassing interest; one of the most difficult of known double stars. System similar to those of α *Phoenicis* and η *Centauri*.

λ_1 336.

O.A. 17158

$\alpha = 17^h\,39^m\,4^s.0$; $\delta = -18°\,36'\,45''.3$

8.8, yellow ; 13.5, bl. yellow

1897.597	96.0	3.51
.597	95.1	3.58
1897.597	95.5	3.54

Preceding of a wide double.

λ_1 337.

Cord. DM. 27°11888

$\alpha = 17^h\,39^m\,12^s.0$; $\delta = -28°\,0'\,37''.6$

8, yellow ; 9.5, bl. yellow

t	θ_o	ρ_o
	°	″
1897.185	10.2	9.89
.485	10.3	10.14
1897.485	10.2	10.01

λ_1 338 *C* = ι_1 *Scorpii.*

Cord. G.C. 24107

$\alpha = 17^h\,40^m\,35^s.4$; $\delta = -40°\,5'\,17''.3$

3. or. yellow ; 14.1, bluish

1897.660	94.6	37.77	C
1897.468	95.0	38.92	See
.660	93.6	38.21	See
.660	94.5	38.08	See
1897.596	94.4	38.40	See

λ_1 339.

Cord. Z.C. 17^h2653

$\alpha = 17^h\,40^m\,48^s.4$; $\delta = -43°\,24'\,23''.4$

7, yellow ; 10.5, purple

1897.703	337.1	14.11
.703	336.7	13.70
1897.703	337.0	13.90

λ_1 340 = *G Scorpii.*

Cord. G.C. 24179

$\alpha = 17^h\,43^m\,2^s.8$; $\delta = -37°\,0'\,41''.7$

A B

3, orange ; 14.9, purple

1897.430	200.8	26.25
.430	200.5	26.52
1897.430	200.6	26.38

System resembling *Aldebaran*, and equally difficult.

C, 14.7, bluish.

A C

1897.430	103.2	41.72

λ_1 341 *C*.

Cord. G.C. 24188

$\alpha = 17^h\,43^m\,20^s.8$; $\delta = -41°\,36'\,57''.8$

8, yellow ; 14, bluish

1897.468	66.7	19.68	C

Very difficult.

λ_1 342 = G 179 *Scorpii.*

Cord. G.C. 24266

$\alpha = 17^h\,46^m\,43^s.2$; $\delta = -34°\,52'\,14''.1$

6.6, orange ; 7.2, orange

1897.627	284.2	0.43
.627	285.1	0.41
1897.627	284.6	0.42

Most interesting system, barely separated; in a great cluster in the Milky Way.

λ_1 343.

Cord. G.C. 24363

$\alpha = 17^h\,51^m\,12^s.4$; $\delta = -35°\,59'\,38''.5$

A B = Syd.$_1$ 306

7.3, yellow ; 8.8, purple

t	θ_o	ρ_o
	°	″
1896.602	14.1	2.8 ±
.663	16.3	3.39
.695	15.3	2.39
1896.653	15.2	2.89

C, 13, purple.

A C

1896.602	[90. ±]	[7. ±]
.663	97.0	11.27
.695	95. ±	10.73
1896.679	96.0	11.00

λ_1 344.

Cord. G.C. 24385

$\alpha = 17^h\,52^m\,4^s.2$; $\delta = -36°\,50'\,59''.1$

8.1, purple ; 13, purplish

1896.698	[170. ±]	[1. ±]
.732	159.8	1.25
.732	155.0	1.63
.734	155.8	1.54
1896.733	156.9	1.47

Nicely separated but delicate.

λ_1 345.

Cord. G.C. 24489

$\alpha = 17^h\,55^m\,48^s.7$; $\delta = -43°\,27'\,38''.7$

6.2, yellow ; 11, purple

1897.753	139.2	16.17
.753	138.5	16.51
1897.753	138.8	16.34

λ_1 346 = *W Sagittarii.*

Cord. G.C. 24577

$\alpha = 17^h\,58^m\,37^s.8$; $\delta = -29°\,35'\,3''.2$

A B

4.9, or. yellow ; 14.6, bluish

1897.485	233.9	33.33
.485	232.9	33.44
1897.485	233.4	33.38

C, 13.9, bluish.

A C

1897.485	99.2	47.30

Faint companions to a well known variable.

λ_1 347.

Cord. Z.C. 18^h244

$\alpha = 18^h\,5^m\,17^s.7$; $\delta = -37°\,3'\,43''.9$

8.3, yellow ; 8.6, yellow

1896.668	51.8	0.45
.698	54.8	0.61
.698	54.3	0.51
1896.688	53.6	0.51

Fine system.

λ_1 348 *C*.

Cord. G.C. 24847

$\alpha = 18^h\, 8^m\, 59^s.4$; $\delta = -24^\circ\, 1'\, 37''.7$

9, yellow ; 10, yellow

t	θ_o	ρ_o	
	°	″	
1897.671	310.3	0.63	C
.671	310.0	0.71	C
1897.671	310.1	0.67	C

Nice system, well separated.

λ_1 349.

Anon., near Cord. G.C. 24860.

$\alpha = 18^h\, 9^m\, 39^s.0$; $\delta = -18^\circ\, 40'\, 37''.5$

8, yellow ; 13.7, bluish

1897.747	121.8	10.83
.747	123.6	11.34
1897.747	122.7	11.08

λ_1 350 *C* = δ *Sagittarii.*

Cord. G.C. 24987

$\alpha = 18^h\, 14^m\, 35^s.3$; $\delta = -29^\circ\, 52'\, 12''.8$

3, or. yellow ; 14.5, bluish

1896.709	[270. ±]	[28. ±]	C
.731	276.4	25.78	See
1896.720	276.4	25.78	See

C, 15, bluish.

A C

1896.731	165.1	40.14	See

D, 13, bluish.

A D

1896.731	221.3	58.13	See

Very faint companions discovered by Mr. COGSHALL.

λ_1 351 = ϵ *Sagittarii.*

Cord. G.C. 25060

$\alpha = 18^h\, 17^m\, 32^s.2$; $\delta = -34^\circ\, 25'\, 50''.5$

2, orange ; 14.3, bluish

1896.714	292.7	31.36
.728	297.4	33.19
1896.721	295.1	32.48

Difficult.

λ_1 352.

Cord. Z.C. 18^h1117

$\alpha = 18^h\, 19^m\, 12^s.2$; $\delta = -30^\circ\, 16'\, 9''.5$

7.5, yellow ; 13.9, dingy

1897.706	72.2	2.98
.706	72.3	2.94
1897.706	72.3	2.96

Very difficult system.

λ_1 353 = G 75 *Sagittarii.*

Cord. G.C. 25259

$\alpha = 18^h\, 24^m\, 31^s.2$; $\delta = -33^\circ\, 3'\, 17''.3$

A B

6, yellow ; 6, yellow

1897.742	265 ±	0.18 ±

Just divided with power of 1500.

C, 11.6, purple.

λ_1 353 = G 75 *Sagittarii* (cont.)

$\frac{AB}{2}$, $C = \beta 1128$

t	θ_o	ρ_o
	°	″
1897.717	199.5	3.22
.742	197.7	3.87
.742	196.6	4.02
1897.734	197.9	3.70

D, 13, purplish.

$\frac{AB}{2}$, *D*

1897.742	337.2	29.26

Quadruple of great interest.

λ_1 354 = G 76 *Sagittarii.*

Cord. G.C. 25285

$\alpha = 18^h\, 25^m\, 34^s.8$; $\delta = -18^\circ\, 28'\, 15''.5$

5.8, yellow ; 14.7, bluish

1897.736	182.9	25.54

Faint companion to bright star.

λ_1 355.

Cord. G.C. 25376

$\alpha = 18^h\, 29^m\, 29^s.6$; $\delta = -19^\circ\, 20'\, 48''.3$

6, orange ; 13.9, purple

1897.720	238.9	13.15
.720	239.3	12.92
.747	238.0	12.47
.747	238.7	12.26
1897.734	238.9	12.95

λ_1 356.

Cord. G.C. 25536

$\alpha = 18^h\, 36^m\, 19^s.0$; $\delta = -29^\circ\, 34'\, 23''.6$

7.8, yellow ; 8, yellow

1897.706	133.5	3.97
.706	134.5	3.94
1897.706	134.0	3.96

λ_1 357.

Cord. G.C. 25575

$\alpha = 18^h\, 38^m\, 0^s.1$; $\delta = -29^\circ\, 31'\, 39''.5$

A B

8, yellow ; 12.5, purple

1896.772	174.2	2.30

Close, but well separated.

C, 12.3, bluish.

A C

1896.753	288.6	13.46
.772	291.4	13.11
.772	292.8	13.02
1896.766	290.9	13.20

Interesting triple.

λ_1 358.

Cord. G.C. 25591

$\alpha = 18^h\, 38^m\, 33^s.4$; $\delta = -25^\circ\, 53'\, 40''.2$

7.3, yellow ; 8.2, yellow

t	θ_o	ρ_o	
	°	″	
1897.627	29.3	1.92	
.627	29.9	1.84	
1897.627	29.6	1.88	
1897.673	30.2	1.36	C

λ_1 359.

Cord. G.C 25612

$\alpha = 18^h\, 39^m\, 33^s.6$; $\delta = -43^\circ\, 53'\, 25''.9$

7.7, yellow ; 8.2, yellow

1897.427	16.3	0.58
.427	17.5	0.40 ±
1897.427	16.9	0.49

Almost separated.

λ_1 360 = G 99 *Sagittarii.*

Cord. G.C. 25642

$\alpha = 18^h\, 40^m\, 18^s.8$; $\delta = -22^\circ\, 29'\, 47''.9$

5.6, orange ; 14.7, dingy

1897.655	206.8	12.82
.655	205.7	12.81
.660	211.0	12.00
.660	211.6	12.25
.742	209.9	12.78
.742	209.8	12.50
1897.696	209.1	12.52

Exceedingly difficult and interesting system.

λ_1 361.

Cord. G.C. 25714

$\alpha = 18^h\, 43^m\, 6^s.7$; $\delta = -33^\circ\, 42'\, 28''.6$

7.9, yellow ; 8, yellow

1897.625	228.3	1.12
.625	225.8	1.14
1897.625	227.1	1.13

Independently discovered by INNES.

λ_1 362 = G 104 *Sagittarii.*

Cord. G.C. 25735

$\alpha = 18^h\, 43^m\, 44^s.1$; $\delta = -20^\circ\, 26'\, 18''.2$

5.8, orange ; 14.5, bluish

1897.747	0.2	17.24
.747	0.3	16.83
1897.747	0.2	17.03

λ_1 363.

Cord. Z.C. 18^h2567

$\alpha = 18^h\, 48^m\, 1^s.2$; $\delta = -32^\circ\, 33'\, 21''.1$

8.8, yellow ; 11.8, bluish

1896.755	99.0	7.07
.788	97.8	6.70
.788	98.1	6.91
1896.777	98.3	6.90

λ_1 364.

Cord. Z.C. 18^h2643
$\alpha = 18^h\,49^m\,41^s.6$; $\delta = -28^\circ\,15'\,25''.1$
8.1, yellow ; 9, yellow

t	θ_o	ρ_o
	°	″
1897.627	95.6	0.41
.627	97.2	0.42
1897.627	96.4	0.41

Fine close system.

λ_1 365.

Anon.
$\alpha = 18^h\,55^m\pm$; $\delta = -42^\circ\,54'\pm$
8.6, yellow ; 8.8, yellow

1897.753	76.6	4.34
.753	77.0	4.33
1897.753	76.8	4.33

λ_1 366.

Cord. G.C. 26012
$\alpha = 18^h\,55^m\,35^s.1$; $\delta = -42^\circ\,24'\,29''.7$
8.6, yellow ; 9.1, yellow

1897.753	178.2	2.36
.753	180.0	2.31
1897.753	179.1	2.34

Nice little system.

λ_1 367.

Cord. G.C. 26066
$\alpha = 18^h\,57^m\,29^s.1$; $\delta = -34^\circ\,31'\,2''.6$
8, yellow ; 9, bl. yellow

1897.711	9.5	0.86 est. 0″.70
.711	9.8	0.74
1897.711	9.6	0.80

Elegant system.

λ_1 368.

Cord. Z.C. 18^h3023
$\alpha = 18^h\,58^m\,20^s.4$; $\delta = -31^\circ\,5'\,46''.1$
8.1, yellow ; 11.5, bl. yellow

1896.753	306.7	16.81
.775	305.4	16.79
.775	305.0	16.99
1896.768	305.7	16.86

λ_1 369 = *o Sagittarii.*

Cord. G.C. 26102
$\alpha = 18^h\,58^m\,41^s.2$; $\delta = -21^\circ\,53'\,14''.9$
4.5, or. yellow ; 14.5, bluish

1897.742	236.1	34.40
.742	237.2	34.67
1897.742	236.7	34.53

λ_1 370.

Cord. Z.C. 19^h18
$\alpha = 19^h\,2^m\,4^s.3$; $\delta = -35^\circ\,34'\,48''.7$

A B

8.5, yellow ; 11.5, bluish

t	θ_o	ρ_o
	°	″
1896.788	91.3	1.88

C, 10.2, bl. yellow

A C = Cord. dpl. II

1896.758	63.6	6.45
.788	68.4	7.61
1896.773	66.0	7.03

D, 12, bluish.

A D

1896.758	147.3	12.11

E, 14, bluish.

D E

1896.758	130.8	5.18

λ_1 371.

Cord. D.M. 22°13701
$\alpha = 19^h\,6^m\,7^s.1$; $\delta = -22^\circ\,5'\,27''.2$
7.5, yellow ; 13.4, purple

1897.720	331.1	7.88
.720	329.2	7.80
1897.720	330.1	7.84

λ_1 372.

Cord. G.C. 26425
$\alpha = 19^h\,12^m\,28^s.6$; $\delta = -33^\circ\,27'\,14''.8$
7.9, yellow ; 8, yellow

1897.657	142.0	0.41
.657	141.6	0.44
.793	309.4	0.43
.793	308.9	0.43
1897.725	135.5	0.43

Elegant system. Independently found by INNES.

λ_1 373.

Cord. Z.C. 19^h766
$\alpha = 19^h\,19^m\,18^s.0$; $\delta = -42^\circ\,5'\,6''.9$
8.2, yellow ; 9.5, bl. yellow

1897.793	28.9	1.24
.793	28.3	1.07
1897.793	28.6	1.15

Nice close system.

λ_1 374.

Anon.
$\alpha = 19^h\,20^m\,21^s.3$; $\delta = -40^\circ\,14'\,13''.2$
10, yellowish ; 11.2, yellowish

1896.602	[110. ±]	[3. ±]
.605	124.8	5.32
.701	123.2	5.81
.701	123.2	5.30
1896.669	123.7	5.48

λ_1 375.

Cord. G.C. 26615
$\alpha = 19^h\,20^m\,32^s.6$; $\delta = -26^\circ\,30'\,59''.1$
7.1, yellow ; 12.2, bluish

t	θ_o	ρ_o
	°	″
1897.627	166.6	12.46
.627	166.6	12.68
1897.627	166.6	12.57

λ_1 376.

Cord. Z.C. 19^h848
$\alpha = 19^h\,21^m\,9^s.6$; $\delta = -31^\circ\,34'\,52''.0$
8.6, yellow ; 8.8, yellow

1897.657	116.8	0.68
.657	117.0	0.72
1897.657	116.9	0.70

Well separated.

λ_1 377.

Cord. Z.C. 19^h895
$\alpha = 19^h\,22^m\,13^s.9$; $\delta = -32^\circ\,30'\,31''.3$
8, yellow ; 9.3, bl. yellow

1897.655	297.0	1.78
.655	296.3	1.67
1897.655	296.7	1.73

λ_1 378.

Cord. DM. 32°15208
$\alpha = 19^h\,22^m\,16^s.4$; $\delta = -32^\circ\,11'\,35''.6$
8.7, yellow ; 10.7, bl. yellow

1896.755	4.3	10.15
.775	359.6	10.63
.775	0.9	10.62
1896.768	1.6	10.47

λ_1 379.

Anon., near Cord. G.C. 26645
$\alpha = 19^h\,22^m\,27^s.4$; $\delta = -36^\circ\,11'\,17''.8$
8.8, yellow ; 12.5, bluish

1896.717	271.2	17.15
.722	270.2	17.29
.722	270.7	17.46
1896.721	270.7	17.30

Place exact.

λ_1 380.

Cord. DM. 38°13542
$\alpha = 19^h\,25^m\,51^s.5$; $\delta = -38^\circ\,21'\,40''.3$
9.7, yellowish ; 10.3, yellowish

1896.638	30.7	6.92
.668	29.0	6.89
.698	30.0	6.90
1896.668	29.9	6.90

λ_1 381.

Cord. G.C. 26744

$\alpha = 19^h\,26^m\,0^s.4$; $\delta = -27°\,57'\,37''.5$

8.5, yellow ; 8.7, yellow

t	θ_o	ρ_o
	°	″
1897.717	13.1	1.54
.717	13.2	1.56
1897.717	13.1	1.55

λ_1 382.

Cord. Z.C. 19^h1130

$\alpha = 19^h\,28^m\,12^s.5$; $\delta = -41°\,38'\,7''.8$

7.9, yellow ; 8.6, bl. yellow

1897.793	293.7	2.15
.793	292.6	2.06
1897.793	293.1	2.10

Nice system.

λ_1 383.

Anon.

$\alpha = 19^h\,29^m\pm$; $\delta = -19°\,25'\pm$

9, yellow ; 10.2, purplish

1897.791	245.7	4.05
.791	246.7	3.93
1897.791	246.2	3.99

λ_1 384.

Cord. G.C. 26821

$\alpha = 19^h\,29^m\,38^s.0$; $\delta = -23°\,31'\,41''.4$

7.9, yellow ; 11.5, bluish

1897.660	167.1	5.99
.660	166.9	6.23
1897.660	167.0	6.11

λ_1 385.

SD. 21°5451

$\alpha = 19^h\,31^m\,7^s.7$; $\delta = -21°\,51'\,19''.8$

A B

7.2, or. yellow ; 14.9, dingy

1897.655	7.0	3.95
.655	6.8	3.81
1897.655	6.9	3.88

Exceedingly difficult.

C, 11, bl. purple.

A C

1897.655	300.1	27.81

λ_1 386.

Cord. G.C. 26876

$\alpha = 19^h\,32^m\,18^s.6$; $\delta = -41°\,46'\,15''.3$

7.6, yellow ; 11.2, bluish

1897.793	110.6	13.64
.793	110.2	13.60
1897.793	110.4	13.62

λ_1 387.

Cord. G.C. 26875

$\alpha = 19^h\,32^m\,31^s.0$; $\delta = -45°\,30'\,18''.3$

7.9, yellow ; 8, yellow

t	θ_o	ρ_o
	°	″
1897.777	358.5	0.41
.777	358.9	0.43
1897.777	358.7	0.42

Exceedingly close; fine double.

λ_1 388.

Cord. Z.C. 19^h1338

$\alpha = 19^h\,32^m\,52^s.3$; $\delta = -39°\,58'\,14''.7$

8, yellow ; 10.7, purple

1897.777	177.1	2.85
.777	177.0	2.82
1897.777	177.0	2.83

λ_1 389 = G 217 *Sagittarii.*

Cord. G.C. 26915

$\alpha = 19^h\,33^m\,49^s.1$; $\delta = -23°\,39'\,18''.6$

7, yellow ; 7.5, yellow

1897.660	334.0	0.18
.660	330.4	0.16
.731	333.5	0.15 ±
.731	334.0	0.15 ±
.804	331.8	0.16 ±
.804	327.6	0.15 ±
1897.731	331.9	0.16

System of highest interest; elongated like an egg in the ratio of 2 : 3; the closest double star I have ever measured; not a trace of separation.

This remarkable object is the preceding corner of a small rhombus; and was swept up accidentally on four occasions, and each time recognized as double, with a power of only 500.

λ_1 390.

O.A. 19840

$\alpha = 19^h\,34^m\,16^s.6$; $\delta = -20°\,46'\,36''.0$

7, yellow ; 13.7, bluish

1897.750	84.0	15.28
.750	83.3	15.31
1897.750	83.7	15.30

λ_1 391.

Cord. DM. 30°17293

$\alpha = 19^h\,35^m\,43^s.1$; $\delta = -30°\,33'\,56''.2$

8.8, yellow ; 10.4, bl. yellow

1896.753	35.2	6.39
.753	36.9	6.44
.773	36.5	6.24
1896.766	36.2	6.36

λ_1 392.

Cord. Z.C. 19^h1506

$\alpha = 19^h\,36^m\,58^s.1$; $\delta = -39°\,8'\,30''.1$

7.9, or. yellow ; 12.3, bluish

t	θ_o	ρ_o
	°	″
1896.641	122.0	9.32
.663	128.8	9.42
.736	126.6	9.44
.736	130.0	9.28
1896.694	126.8	9.39

s. f. of a wide double.

λ_1 393.

Cord. G.C. 27018

$\alpha = 19^h\,40^m\,11^s.0$; $\delta = -27°\,52'\,44''.5$

8, yellow ; 8, yellow

1897.717	210.0	0.18 ±
.717	212.5	0.18 ±
1897.717	211.2	0.18

Exceedingly close.

λ_1 394.

Cord. G.C. 27069

$\alpha = 19^h\,40^m\,21^s.7$; $\delta = -25°\,7'\,16''.3$

7.9, yellow ; 8.4, bl. yellow

1897.644	289.4	0.37
.644	289.9	0.35
.824	296.5	0.39
.824	298.5	0.37
1897.734	293.6	0.37

Fine system, separated.

λ_1 395.

Cord. G.C. 27106

$\alpha = 19^h\,42^m\,12^s.1$; $\delta = -26°\,54'\,19''.5$

8.5, wh. yellow ; 8.7, wh. yellow

1897.717	105.6	2.08
.717	106.5	1.94
1897.717	106.1	2.01

λ_1 396.

Cord. G.C. 27141

$\alpha = 19^h\,43^m\,55^s.9$; $\delta = -23°\,58'\,7''.8$

8, yellow ; 11.3, purple

1897.655	271.8	7.01
.655	271.9	7.06
.660	270.7	6.89
.660	270.3	6.92
1897.657	271.2	6.97

λ_1 397.

Cord. DM. 36°13735

$\alpha = 19^h\,45^m\,18^s.4$; $\delta = -36°\,47'\,12''.5$

8.6, yellow ; 9.4, bl. yellow

1896.758	184.0	7.32
.799	185.3	8.81
.799	185.7	8.61
1896.786	185.0	8.25

λ_1 398.

Cord. G.C. 27265

$\alpha = 19^{h}\,49^{m}\,29^{s}.5$; $\delta = -38^{\circ}\,35'\,44''.9$

7.4, reddish ; 13.3, bluish

t	θ_0	ρ_0
	°	″
1896.701	302.6	9.58
.722	307.1	10.83
.722	308.6	10.32
.766	308.2	10.24
.788	308.8	10.76
.788	308.7	10.44
1896.746	307.3	10.36
1897.736	311.0	10.87
.736	310.2	10.73
1897.736	310.6	10.80

System of high interest; miniature of *Aldebaran.*

λ_1 399.

Cord. DM. 36°13788

$\alpha = 19^{h}\,50^{m}\,17^{s}.6$; $\delta = -36^{\circ}\,38'\,33''.5$

8.9, yellow ; 13.2, bluish

1896.758	31.7	4.69
.775	33.4	4.22
.775	32.1	4.29
1896.770	32.4	4.40

Very delicate.

λ_1 400.

Cord. G.C. 27374

$\alpha = 19^{h}\,54^{m}\,20^{s}.6$; $\delta = -24^{\circ}\,13'\,41''.5$

7.9, yellow ; 10, purple

1897.655	31.7	1.58
.655	30.5	1.43
.711	29.2	1.34
.711	31.2	1.26
.731	30.5	1 47
.731	29.3	1.30
1897.700	30.4	1.38

Interesting system.

λ_1 401 = G 264 *Sagittarii.*

Cord. G.C. 27406

$\alpha = 19^{h}\,55^{m}\,27^{s}.4$; $\delta = -23^{\circ}\,0'\,43''.5$

5.2, or. yellow ; 14.5, bl. purple

1897.824	220.7	13.03

Companion very difficult.

λ_1 402.

Cord. G.C. 27441

$\alpha = 19^{h}\,56^{m}\,58^{s}.0$; $\delta = -36^{\circ}\,52'\,28''.0$

7.3, yellow ; 12.5, bluish

1896.717	309.9	21.75
.728	310.2	19.75
1896.723	310.0	20.75

λ_1 403.

Cord. G.C. 27448

$\alpha = 19^{h}\,57^{m}\,10^{s}.3$; $\delta = -36^{\circ}\,20'\,19''.1$

A B

7.4, orange ; 7.7, orange

t	θ_0	ρ_0
	°	″
1896.706	116.8	0.67
.722	119.5	0.52
.772	114.3	0.63
1896.734	116.9	0.61

Very fine pair. *C*, 14, bl. purple.

$\frac{A\,B}{2}, C$

1896.706	15. ±	5.9 ±
.722	24.8	7.58
1896.714	24.8	7.58

λ_1 404 = G 272 *Sagittarii.*

Cord. G.C. 27486

$\alpha = 19^{h}\,59^{m}\,9^{s}.3$; $\delta = -33^{\circ}\,16'\,58''.9$

A B

7.5. yellow ; 9.5, yellow

1897.736	64.2	0.47
.736	66.4	0.52
1897.736	65.3	0.49

Fine system. *C*, 13.3, bluish.

$\frac{A\,B}{2}, C$

1896.703	181.5	20.78
.728	181.5	21.26
.788	181.5	21.03
1896.740	181.2	21.02
1897.736	181.2	22.63

λ_1 405.

Cord. G.C. 27514

$\alpha = 20^{h}\,0^{m}\,29^{s}.6$; $\delta = -28^{\circ}\,39'\,24''.6$

8, yellow ; 8.4, yellow

1897.657	234.0	0.50
.657	232.8	0.47
1897.657	233.4	0.48

Elegant system.

λ_1 406.

O.A. 20244

$\alpha = 20^{h}\,1^{m}\,32^{s}.7$; $\delta = -19^{\circ}\,51'\,33''.4$

7.9, yellow ; 10.8, purple

1897.753	1.0	2.68
.753	1.4	2.78
1897.753	1.2	2.73

λ_1 407.

Cord. Z.C. 20h20

$\alpha = 20^{h}\,2^{m}\,21^{s}.5$; $\delta = -39^{\circ}\,0'\,49''.0$

8.4, yellow ; 8.6, yellow

t	θ_0	ρ_0
	°	″
1896.613	261.8	3.44
.663	260.0	3.45
.775	262.3	2.51
1896.684	261.4	3.13

Beautiful system.

λ_1 408.

Cord. D.M. 32°15777

$\alpha = 20^{h}\,5^{m}\,19^{s}.0$; $\delta = -32^{\circ}\,8'\,34''.9$

8, orange ; 15, dingy

1896.755	197.0	14.27
.775	192.6	14.23
.775	191.8	15.72
1896.768	193.8	14.74

Extremely difficult, companion shining with a dull luster.

λ_1 409.

Anon.

$\alpha = 20^{h}\,6^{m}\,40^{s}\pm$; $\delta = -20^{\circ}\,33'\pm$

8 9, yellow ; 11.8, bluish

1897.804	28.9	5.23
.804	30.3	5.24
1897.804	29.6	5.23

λ_1 410.

Cord. G.C. 27677

$\alpha = 20^{h}\,7^{m}\,20^{s}.0$: $\delta = -36^{\circ}\,20'\,32''.1$

6.5, yellow ; 10.2, purple

1896.717	10.8	2.46
.717	10.0	2.71
.788	9.7	3.04
.788	9.0	3.30
1896.753	9.6	2.88

Splendid system.

λ_1 411.

O.A. 20331

$\alpha = 20^{h}\,8^{m}\,22^{s}.4$; $\delta = -20^{\circ}\,32'\,25''.9$

8, yellow ; 13.9, bluish

1897.747	4.8	2.74
.747	5.1	2.40
1897.747	4.9	2.57

Companion difficult.

λ_1 412 ; *deep red.*

Cord. G.C. 27776.

$\alpha = 20^{h}\,11^{m}\,15^{s}.3$; $\delta = -21^{\circ}\,37'\,31''.0$

6.3, deep red ; 15, bluish

1897.775	211.4	25.56
.791	209.8	25.86
.791	209.4	26.17
1897.786	210.2	25.86

Blood red : one of the most remarkable objects I have ever seen. I know of no other star which can compare with this in depth of color. Companion very difficult ; remarkable system.

λ_1 413.

Anon., near Cord. Z.C. 20h327

$\alpha = 20^h\,12^m\,0^s.8$; $\delta = -33^\circ\,16'\,39''.1$

A B

10.5, bluish ; 13.7, bluish

t	θ_o	ρ_o
	°	″
1896.753	26.0	16.75
.785	22.0	16.28
.802	28.9	16.25
1896.780	25.6	16.43

C, 14, bluish.

B C

1896.753	142.4	3.02
.785	138.8	2.67
.802	141.2	3.28
1896.783	140.8	2.99

Faint object; measured because of its peculiar nature.

λ_1 414.

Cord. G.C. 27849

$\alpha = 20^h\,13^m\,22^s.0$; $\delta = -27^\circ\,29'\,42''.8$

8.5, yellow ; 9.1, bl. yellow

1897.717	52.3	2.33
.717	51.5	2.48
1897.717	51.9	2.41

λ_1 415.

Cord. G.C. 27825

$\alpha = 20^h\,13^m\,52^s.2$; $\delta = -45^\circ\,51'\,25''.3$

7.9, yellow ; 11.3, purple

1897.777	80.0	11.04
.777	78.6	11.02
1897.777	79.3	11.03

λ_1 416.

Cord. G.C. 27894

$\alpha = 20^h\,16^m\,19^s.0$; $\delta = -28^\circ\,2'\,40''.8$

A B

9, yellow ; 9, yellow

1897.657	63.2	0.95
.657	63.4	1.05
1897.657	63.3	1.00

C, 13, bluish.

$\frac{A\,B}{2}$, C

1897.657	254.4	27.30

λ_1 417.

Cord. DM. 35°14087

$\alpha = 20^h\,17^m\,21^s.5$; $\delta = -35^\circ\,42'\,24''.8$

7.7, yellow ; 12.5, bl. purple

1896.605	141.8	4.11
.649	138.0	3.34
.758	140.9	2.95
.799	141.1	3.42
.799	141.2	3.29
1896.722	140.6	3.42

The northern star of a wide double.

λ_1 418.

Cord. DM. 25°14744

$\alpha = 20^h\,18^m\,11^s.7$; $\delta = -25^\circ\,17'\,53''.1$

8.1, yellow ; 9.2, purple

t	θ_o	ρ_o
	°	″
1897.824	53.2	2.71
.824	52.9	3.04
1897.824	53.0	2.87

λ_1 419.

Anon.

$\alpha = 20^h\,22^m\,34^s.0$; $\delta = -32^\circ\,15'\,33''.8$

9, yellow ; 13.5, bluish

1896.753	63.4	6.49
.788	66.7	6.34
.788	66.5	6.92
1896.776	65.5	6.58

The northern star of a wide double.

λ_1 420.

Cord. DM. 22°14788

$\alpha = 20^h\,26^m\,41^s.9$; $\delta = -22^\circ\,1'\,48''.0$

8, yellow ; 13, bl. purple

1897.720	88.6	1.57
.720	88.1	1.48
1897.720	88.3	1.52

Exceedingly difficult, interesting star.

λ_1 421.

Cord. Z.C. 20h898

$\alpha = 20^h\,28^m\,43^s.0$; $\delta = -40^\circ\,37'\,33''.1$

8, yellow ; 13.8, bluish

1896.766	273.2	8.08
.802	280.0	9.10
1896.784	276.6	8.59

λ_1 422.

Cord. Z.C. 20h1050

$\alpha = 20^h\,33^m\,35^s.6$; $\delta = -39^\circ\,41'\,12''.1$

7.5, yellow ; 14, bluish

1897.793	225.6	18.80
.793	224.7	18.80
1897.793	225.1	18.80

λ_1 123.

Cord. G.C. 28308

$\alpha = 20^h\,34^m\,4^s.0$; $\delta = -29^\circ\,13'\,26''.0$

8.2, yellow ; 9.5, bl. yellow

1897.657	20.9	0.71
.657	20.2	0.73
1897.657	20.5	0.72

Nice close system.

λ_1 424.

Cord. Z.C. 20h1101

$\alpha = 20^h\,34^m\,50^s.7$; $\delta = -33^\circ\,47'\,47''.1$

9.5, bl. yellow ; 11.5, bl. yellow

t	θ_o	ρ_o
	°	″
1896.775	334.1	11.66
.802	334.2	11.66
.802	334.0	11.70
1896.787	334.1	11.67

λ_1 425.

Cord. G.C. 28374

$\alpha = 20^h\,36^m\,58^s.4$; $\delta = -29^\circ\,7'\,39''.1$

7.5, yellow ; 12, purplish

1896.709	224.1	7.80
.731	225.7	7.80
.731	224.0	7.81
1896.724	224.6	7.80

λ_1 426.

Cord. DM. 24°16238

$\alpha = 20^h\,38^m\,30^s.2$; $\delta = -24^\circ\,0'\,49''.6$

8.6, yellow ; 12.8, bluish

1896.818	89.2	6.56
.838	97.3	8.52
.838	96.7	8.38
1896.831	94.4	7.82

λ_1 427.

Cord. DM. 23°16453

$\alpha = 20^h\,38^m\,47^s.5$; $\delta = -23^\circ\,33'\,3''.0$

8.3, yellow ; 13.5, purplish

1896.818	183.4	1.59
.843	175.2	1.35
.845	173.6	1.77
1896.859	177.4	1.57

Fine system.

λ_1 428 = G 21 *Microscopii.*

Cord. G.C. 28424

$\alpha = 20^h\,38^m\,52^s.3$; $\delta = -35^\circ\,31'\,38''.0$

7.5, yellow ; 15, dingy

1896.668	193.7	4.14
.696	183.9	4.29
.696	185.5	4.79
1896.686	187.7	4.41

Remarkable system; the companion shining with a dull luster as if by reflected light. The color of the companion is dark brown, or dingy, and it can be seen only under the best conditions.

λ_1 429.

Cord. Z.C. 20h1442

$\alpha = 20^h\,45^m\,38^s.4$; $\delta = -38^\circ\,32'\,13''.6$

8.0, yellow ; 15, dingy

1896.698	190.2	2.45
.722	185.5	3.29
.722	188.1	2.83
1896.714	187.9	2.86

Companion shines with a dull light, as in the case of the last star. Of the last degree of difficulty.

λ_1 430.

Cord. Z.C. $20^{h}1451$

$\alpha = 20^{h}\,45^{m}\,50^{s}.8$; $\delta = -34^{\circ}\,15'\,18''.1$

7.7, orange ; 12.3, indigo blue

t	θ_0	ρ_0
	°	″
1896.755	350.2	13.54
.772	346.6	13.39
.772	346.8	13.97
1896.767	347.9	13.63

Companion indigo blue.

λ_1 431 = G 59 *Capricorni.*

Cord. G.C. 28648

$\alpha = 20^{h}\,47^{m}\,50^{s}.3$: $\delta = -19^{\circ}\,29'\,27''.7$

7.2, yellow ; 13.7, bl. purple

1897.799	341.6	2.79
.799	341.9	2.46
1897.799	341.7	2.63

λ_1 432.

O.A. 20936

$\alpha = 20^{h}\,48^{m}\,24^{s}.4$; $\delta = -19^{\circ}\,22'\,21''.2$

8.2, yellow ; 13.3, bluish

1897.775	324.3	2.24
.775	324.0	2.31
1897.775	324.1	2.27

Faint companion.

λ_1 433.

Cord. DM. 24°16378

$\alpha = 20^{h}\,51^{m}\,24^{s}.9$; $\delta = -24^{\circ}\,40'\,20''.2$

9, yellow ; 9.3, yellow

1897.655	40.9	2.52
.655	40.4	2.49
1897.655	40.6	2.50

λ_1 434.

Cord. DM. 22°15096

$\alpha = 20^{h}\,51^{m}\,31^{s}.3$; $\delta = -22^{\circ}\,1'\,2''.2$

7.5, yellow ; 11.3, purple

1897.804	148.9	4.61
.804	148.0	4.48
1897.804	148.4	4.54

λ_1 435 = G 46 *Microscopii.*

Cord. G.C. 28837

$\alpha = 20^{h}\,57^{m}\,12^{s}.4$; $\delta = -28^{\circ}\,7'\,28''.3$

7.2, or. yellow ; 8.2, or. yellow

1897.657	289.5	0.21 est. 0″.19
.657	290.0	0.17
1897.657	289.7	0.19

Just barely divided with 1500. Fine system.

λ_1 436.

Cord. G.C. 28857

$\alpha = 20^{h}\,57^{m}\,57^{s}.6$; $\delta = -24^{\circ}\,43'\,2''.1$

8, yellow ; 8.3, yellow

t	θ_0	ρ_0
	°	″
1897.655	86.9	0.25
.655	87.6	0.23
.777	268.4	0.20
.777	270.2	0.24
1897.711	88.3	0.23

Very fine system, barely separated with 1000.

λ_1 437 = η *Microscopii.*

Cord. G.C. 28904

$\alpha = 20^{h}\,59^{m}\,55^{s}.3$; $\delta = -41^{\circ}\,47'\,4''.8$

4.1, orange ; 14.5, bluish

1897.791	39.8	44.38
.791	39.4	43.77
1897.791	39.6	44.07

Suspect a third companion in 133°, 10″. 14 mag.

λ_1 438.

Cord. G.C. 28913

$\alpha = 21^{h}\,0^{m}\,11^{s}.3$; $\delta = -35^{\circ}\,1'\,39''.4$

7.3, yellow ; 14.5, bl. purple

1896.810	283.5	8.81
.851	284.2	8.55
.851	282.1	7.58
1896.838	283.3	8.31

Difficult system.

λ_1 439 = *A Capricorni.*

Cord. G.C. 28951

$\alpha = 21^{h}\,1^{m}\,16^{s}.8$; $\delta = -25^{\circ}\,24'\,19''.0$

4.9, orange ; 12.2, purple

1897.660	184.8	26.55
.660	184.7	26.59
.742	186.5	26.18
.742	186.0	26.21
.799	186.7	26.30
.799	185.7	26.39
1897.734	185.7	26.37

λ_1 440.

Cord. Z.C. $21^{h}84$

$\alpha = 21^{h}\,4^{m}\,9^{s}.1$; $\delta = -26^{\circ}\,27'\,24''.5$

7.9, yellow ; 12.8, bluish

1896.835	71.8	9.53
.838	68.8	9.89
.838	69.5	9.68
1896.837	70.0	9.70
1897.627	69.4	9.97
.627	70.0	9.93
1897.627	69.7	9.95

λ_1 441.

Cord. DM. 25°15323

$\alpha = 21^{h}\,9^{m}\,48^{s}.4$; $\delta = -24^{\circ}\,59'\,17''.9$

8.2, yellow ; 8.3, yellow

t	θ_0	ρ_0
	°	″
1897.655	16.6	1.96
.655	17.0	2.00
1897.655	16.8	1.98

λ_1 442.

Cord. DM. 39 14190

$\alpha = 21^{h}\,11^{m}\,22^{s}.4$; $\delta = -39^{\circ}\,36'\,7''.5$

10.3, white ; 12, white

1896.600	31.0	4.75
.649	30.7	5.26
.663	31.7	5.90
1896.637	31.1	5.30

λ_1 443.

Cord. Z.C. $21^{h}345$

$\alpha = 21^{h}\,12^{m}\,55^{s}.7$; $\delta = -27^{\circ}\,2'\,2''.7$

7, yellow ; 10.8, bl. yellow

1897.627	275.9	2.11
.627	275.5	1.96
1897.627	275.7	2.03

λ_1 444 *C.*

Cord. Z.C. $21^{h}370$

$\alpha = 21^{h}\,13^{m}\,45^{s}.6$; $\delta = -24^{\circ}\,11'\,30''.1$

7.5, yellow ; 14, bluish

1897.589	229.6	11.58	C
.589	229.9	11.87	C
1897.589	229.7	11.72	C
1897.660	231.7	12.50(1)	See
.660	231.8	12.76	See
1897.660	231.7	12.63	See

(1) Bad seeing, very difficult.

λ_1 445.

Cord. Z.C. $21^{h}556$

$\alpha = 21^{h}\,19^{m}\,25^{s}.6$; $\delta = -39^{\circ}\,38'\,36''.7$

8.6, yellow ; 11.8, bluish

1896.760	218.2	2.04
.775	220.2	2.04
.775	220.3	1.78
1896.770	219.6	1.95

Interesting physical system.

λ_1 446 = ζ *Capricorni.*

Cord. G.C. 29382

$\alpha = 21^{h}\,20^{m}\,57^{s}.5$; $\delta = -22^{\circ}\,50'\,41''.0$

4, orange ; 14.0, bluish

1896.802	12.7	21.18
.810	14.0	21.64
.810	15.2	21.95
1896.808	14.0	21.59
1897.747	13.4	21.30
.747	13.5	21.40
1897.747	13.4	21.35

λ_1 447.

Cord. G.C. 29423

$\alpha = 21^h\,23^m\,4^s.4$; $\delta = -39^\circ\,15'\,51''.8$

7.8, or. yellow ; 12, purple

t	θ_o	ρ_o
	°	″
1896.608	22.8	8.41
.638	22.5	8.68
.649	24.7	6.51
.663	27.4	7.24
.668	24.3	6.86
1896.645	24.4	7.54

Companion difficult.

Independently noted by INNES one day after it was found at Flagstaff.

λ_1 448.

Cord. G.C. 29468

$\alpha = 21^h\,24^m\,38^s.3$; $\delta = -24^\circ\,51'\,54''.2$

7.9, yellow ; 11.9, bl. purple

1897.655	247.0	1.25
.655	246.5	1.25
.711	251.5	1.27
.711	251.4	1.40
1897.684	249.1	1.29

Fine close system, very difficult.

λ_1 449 = G 102 *Capricorni.*

Cord. G.C. 29485

$\alpha = 21^h\,25^m\,48^s.9$; $\delta = -19^\circ\,40'\,36''.6$

6, yellow ; 12.8, purple

1897.736	196.3	1.76
.736	197.6	1.89
1897.736	197.0	1.82

Most interesting system, resembling 85 *Pegasi:* extremely difficult.

λ_1 450.

Cord. G.C. 29585

$\alpha = 21^h\,30^m\,54^s.6$; $\delta = -33^\circ\,57'\,12''.6$

8.6, yellow ; 13.2, bluish

1896.755	256.3	11.04
.775	251.4	11.29
.775	250.9	11.21
1896.769	252.9	11.18

λ_1 451.

Cord. G.C. 29634

$\alpha = 21^h\,33^m\,26^s.3$; $\delta = -30^\circ\,45'\,19''.3$

8.1, or. yellow ; 13, bluish

1896.766	256.4	12.30
.775	256.7	11.66
.775	257.1	11.86
1896.772	256.7	11.94

λ_1 452.

Cord. G.C. 29665

$\alpha = 21^h\,35^m\,15^s.6$; $\delta = -26^\circ\,17'\,56''.3$

8.2, yellow ; 13.5, bluish

1896.835	103.5	11.00
.838	102.3	11.42
.838	101.4	11.98
1896.837	102.4	11.47

λ_1 453.

Cord. G.C. 29688

$\alpha = 21^h\,36^m\,16^s.2$; $\delta = -25^\circ\,6'\,30''.1$

7, yellow ; 12.8, bluish

t	θ_o	ρ_o
	°	″
1897.747	324.7	11.72
.717	325.1	12.30
1897.717	324.9	11.96

λ_1 454 = G 112 *Capricorni.*

Cord. G.C. 29692

$\alpha = 21^h\,36^m\,19^s.0$; $\delta = -23^\circ\,42'\,53''.4$

6, yellow ; 13.5, purple

1897.826	198.6	5.18
.826	197.4	5.16
1897.826	198.0	5.17

Interesting and difficult system.

λ_1 455.

Cord. G.C. 29733

$\alpha = 21^h\,38^m\,37^s.2$; $\delta = -36^\circ\,4'\,18''.1$

7.7, yellow ; 15, purplish or dingy

1896.717	95.2	1.07
.728	95.0	3.54
.728	94.3	3.52
1896.725	94.8	3.71

A remarkable system, companion shining with a dull luster, and on the very limit of vision.

λ_1 456.

O.A. 21613

$\alpha = 21^h\,39^m\,29^s.0$; $\delta = -20^\circ\,34'\,13''.7$

8, yellow ; 12.7, bl. purple

1896.826	57.6	3.23
.851	56.6	4.12
.851	57.5	3.86
1896.843	57.2	3.74

Elegant system.

λ_1 457.

Cord. G.C. 29746

$\alpha = 21^h\,39^m\,35^s.8$; $\delta = -41^\circ\,41'\,19''.7$

8.2, yellow ; 14.1, bluish

1896.813	210.1	10.17
.851	214.9	10.54
.851	214.6	9.95
1896.839	213.2	10.22

λ_1 458.

Cord. G.C. 29770

$\alpha = 21^h\,40^m\,59^s.7$; $\delta = -27^\circ\,3'\,4''.4$

8, yellow ; 8.4, yellow

1897.627	91.9	0.40
.627	93.4	0.43
1897.627	92.6	0.41

Close elegant system.

λ_1 459.

Cord. G.C. 29826

$\alpha = 21^h\,42^m\,59^s.0$; $\delta = -32^\circ\,51'\,53''.1$

8.2, yellowish ; 13.2, purplish

t	θ_o	ρ_o
	°	″
1896.668	167.4	1.36
.676	167.8	1.29
.695	168.6	1.29
1896.680	167.9	1.31

Interesting and difficult system, with a faint dingy companion.

λ_1 460.

O.A. 21684

$\alpha = 21^h\,45^m\,21^s.5$; $\delta = -20^\circ\,45'\,18''.3$

7.6, yellow ; 8.1, yellow

1897.742	112.7	0.48
.742	114.2	0.42
1897.742	113.4	0.45

Elegant close system.

λ_1 461.

Cord. G.C. 29993

$\alpha = 21^h\,50^m\,35^s.3$; $\delta = -27^\circ\,45'\,48''.1$

8.2, yellow ; 13.3, bl. purple

1896.829	60.7	3.32
.843	64.7	3.58
.843	62.6	3.43
1896.832	62.7	3.44

Physical system.

λ_1 462.

Cord. Z.C. 21^h1607

$\alpha = 21^h\,52^m\,39^s.0$; $\delta = -35^\circ\,39'\,29''.2$

8.3, yellow ; 12.5, bluish

1896.758	194.8	9.96
.772	194.3	11.05
.772	194.5	11.14
1896.768	194.5	10.72

λ_1 463.

O.A. 21786

$\alpha = 21^h\,54^m\,4^s.6$; $\delta = -18^\circ\,40'\,41''.9$

7.2, yellow ; 11.5, bl. purple

1897.753	115.5	16.00
.753	116.4	15.75
1897.753	116.0	15.88

λ_1 464 *C.*

SD. 17°6423

$\alpha = 21^h\,57^m\,18^s.0$; $\delta = -16^\circ\,45'\,0''.5$

8, yellow ; 14.5, bluish

1896.826	138.8	12.41	C
.851	140.6	11.44	C
1896.838	139.7	11.92	C

Companion faint.

λ_1 465.

Cord. G.C. 30172

$\alpha = 21^{h}\,58^{m}\,12^{s}.5$; $\delta = -25^{\circ}\,19'\,47''.0$

7.9, yellow ; 14.3, dingy

t	θ_o	ρ_o
	°	″
1897.657	189.5	2.66
.657	189.7	2.73
1897.657	189.6	2.70

Exceedingly difficult.

λ_1 466.

Cord. G.C. 30185

$\alpha = 21^{h}\,58^{m}\,57^{s}.3$; $\delta = -40^{\circ}\,11'\,20''.2$

8.5, yellow ; 9, yellow

1896.638	267.6	1.34
.649	259.9	1.14
.663	266.6	1.57
1896.650	264.7	1.35

Delicate pair near λ *Gruis.*

λ_1 467.

Cord. Z.C. $21^{h}1836$

$\alpha = 21^{h}\,59^{m}\,33^{s}.3$; $\delta = -27^{\circ}\,19'\,59''.5$

8.3, yellow ; 14.5, bluish

1896.829	116.7	8.03
.851	117.7	10.05
.851	118.0	9.0 ±
1896.844	117.5	9.03

Companion faint.

λ_1 468.

Cord. G.C. 30271

$= 22^{h}\,3^{m}\,5^{s}.8$; $\delta = -36^{\circ}\,32'\,40''.7$

8, yellow ; 14.6, bluish

1896.733	[109.5]	26.22
.785	101.8	24.57
.785	102.8	24.17
1896.768	102.3	24.99

λ_1 469.

Cord. G.C. 30274

$\alpha = 22^{h}\,3^{m}\,6^{s}.9$; $\delta = -26^{\circ}\,15'\,30''.2$

8.1, yellow ; 8.3, yellow

1897.747	308.1	0.20 ±
.747	308.4	0.20 ±
1897.747	308.3	0.20 ±

Just separable with 1500; system of high interest.

λ_1 470.

Cord. Z.C. $22^{h}120$

$\alpha = 22^{h}\,4^{m}\,56^{s}.2$: $\delta = -24^{\circ}\,1'\,37''.9$

7.9, yellow ; 8.7, bl. yellow

1897.804	36.6	1.94
.804	36.0	2.03
.826	27.8	1.72
.826	28.5	1.54
1897.815	32.2	1.81

Nice close system.

λ_1 471.

Anon., near Cord. G.C. 30454

$\alpha = 22^{h}\,13^{m}\,1^{s}.5$; $\delta = -28^{\circ}\,38'\,48''.9$

10.7, lt. yellow ; 12, bl. yellow

t	θ_o	ρ_o	
	°	″	
1896.753	30.1	4.79	
.785	[26.8]	4.29	
.785	[23.3]	4.48	
.810	36.8	3.84	
1896.786	33.4	4.35	
1896.802	34.1	5.15	C
.810	33.0	3.63	C
1896.806	33.5	4.34	C

λ_1 472.

Anon. near Cord. G.C. 30519

$\alpha = 22^{h}\,15^{m}\,57^{s}.3$; $\delta = -25^{\circ}\,51'\,45''.7$

11, yellow ; 12.7, yellow

1896.818	56.5	4.17
.838	56.2	4.50
.838	55.1	5.19
1896.832	55.9	4.62

λ_1 473 = ν *Gruis.*

Cord. G.C. 30641

$\alpha = 22^{h}\,22^{m}\,47^{s}.5$; $\delta = -39^{\circ}\,38'\,11''.7$

6, orange ; 14.2, bluish

1896.703	114.7	27.14
.728	114.0	28.75
.728	114.2	27.60
1896.720	114.3	27.83

Very faint companion to a bright star.

λ_1 474.

Cord. G.C. 30666

$\alpha = 22^{h}\,23^{m}\,49^{s}.3$; $\delta = -29^{\circ}\,10'\,13''.6$

7.4, or. yellow ; 8, or. yellow

1896.717	288.5	0.79
.728	290.8	0.47
.728	290.0	0.42
1896.725	289.8	0.56

Fine close double.

λ_1 475.

Cord. Z.C. $22^{h}767$

$\alpha = 22^{h}\,27^{m}\,26^{s}.2$; $\delta = -39^{\circ}\,15'\,11''.7$

8.5, yellow ; 8.9, yellow

1896.668	286.8	0.65
.668	289.7	0.51
.678	302.4	0.51
.695	292.0	0.55
1896.677	292.7	0.55

Elegant system.

λ_1 476.

Cord. G.C. 30976

$\alpha = 22^{h}\,39^{m}\,42^{s}.4$; $\delta = -23^{\circ}\,37'\,39''.6$

8.4, yellow ; 14.8, bluish

t	θ_o	ρ_o
	°	″
1896.826	37.5	3.43
.843	40.0	4.25
.843	41.0	4.09
1896.831	39.5	3.92

Excessively difficult.

λ_1 477.

Cord. G.C. 30974

$\alpha = 22^{h}\,39^{m}\,46^{s}.8$; $\delta = -47^{\circ}\,4'\,29''.9$

6, yellow ; 10, purple

1897.711	139.6	10.95
.711	142.0	10.91
1897.711	140.8	10.93

λ_1 478 = α *Piscis Austrini, Fomalhaut.*

Cord. G.C. 31213

$\alpha = 22^{h}\,52^{m}\,6^{s}.9$; $\delta = -30^{\circ}\,9'\,4''.6$

1, white ; 14.8, bluish

1896.706	36.2	29.98

A very faint companion in the rays of the bright star.

λ_1 479 *C.*

Cord. G.C. 31495

$\alpha = 23^{h}\,7^{m}\,42^{s}.9$: $\delta = -24^{\circ}\,38'\,57''.8$

8.2, yellow ; 14.5, bluish

1896.835	48.8	11.70	C
.843	53.1	12.03	C
.843	55.3	11.86	C
1896.841	52.4	11.86	C
1896.843	55.7	11.57	See
1897.711	55.5	12.10	See
.711	52.7	12.44	See
1897.422	54.6	12.04	See

λ_1 480.

Cord. Z.C. $23^{h}230$

$\alpha = 23^{h}\,9^{m}\,51^{s}.7$: $\delta = -36^{\circ}\,15'\,22''.5$

8.3, yellow ; 8.5, yellow

1896.733	292.6	0.54
.733	290.2	0.60
.772	292.8	0.55
1896.746	291.9	0.56

Most interesting system.

λ_1 481.

Cord. Z.C. $23^{h}265$

$\alpha = 23^{h}\,11^{m}\,1^{s}.4$; $\delta = -26^{\circ}\,53'\,39''.6$

8, yellow ; 8.1, yellow

1897.711	140.5	3.17
.711	140.3	3.07
1897.711	140.4	3.12

λ_1 482.

Cord. G.C. 31619

$\alpha = 23^h\,14^m\,23^s.2$; $\delta = -23^\circ\,46'\,18''.6$

6.7, orange ; 13.7, purple

t	θ_o	ρ_o
	°	″
1897.736	94.2	14.07
.736	95.2	14.15
1897.736	94.7	14.12

λ_1 483.

Anon.

$\alpha = 23^h\,20^m\,34^s.8$; $\delta = -36^\circ\,21'\,43''.8$

9.3, bl. yellow ; 9.8, bl. yellow

1896.755	292.2	0.89
.775	294.6	1.37
.775	297.4	1.25
1896.769	294.7	1.17

Elegant system.

λ_1 484.

Cord. G.C. 31733

$\alpha = 23^h\,20^m\,43^s.6$; $\delta = -23^\circ\,4'\,8''.2$

A B

8, yellow ; 10.8, purple

1897.657	51.8	1.23
.657	53.3	1.27
1897.657	52.6	1.25

C, 12.8, bl. purple.

A C

1897.657	140.3	22.70

λ_1 485 = G 236 *Aquarii.*

Cord. G.C. 31748

$\alpha = 23^h\,21^m\,19^s.1$; $\delta = -22^\circ\,17'\,26''.8$

6, or. yellow ; 12.3, purple

1897.736	130.3	5.60
.736	131.6	5.61
1897.736	130.9	5.60

λ_1 486.

Cord. DM. 23°17927

$\alpha = 23^h\,24^m\,48^s.6$; $\delta = -23^\circ\,14'\,26''.8$

A B

7.5, yellow ; 10.2, bluish

1897.747	55.2	1.50
.747	55.9	1.47
.804	52.1	1.30
.804	52.0	1.32
1897.775	53.8	1.40

C, 12.4, bluish.

A C

1897.747	143.0	23.51
.804	142.4	22.71
1897.775	142.7	23.11

λ_1 487.

Cord. G.C. 31820

$\alpha = 23^h\,25^m\,46^s.2$; $\delta = -33^\circ\,50'\,25''.5$

7.6, yellow ; 8.8, bluish

t	θ_o	ρ_o
	°	″
1896.703	298.0	9.76
.728	296.4	9.97
.728	297.6	10.65
1896.720	297.5	10.12

λ_1 488 = G 7 *Phoenicis.*

Cord. G.C. 31853

$\alpha = 23^h\,27^m\,15^s.3$; $\delta = -45^\circ\,40'\,25''.5$

5.5, or. yellow ; 12, purple

1897.799	337.3	19.08
.799	337.0	18.76
1897.799	337.2	18.92

λ_1 489 = G 17 *Sculptoris.*

Cord. G.C. 31880

$\alpha = 23^h\,28^m\,24^s.8$; $\delta = -36^\circ\,49'\,1''.1$

7.8, yellow ; 11.3, bluish

1896.733	144.1	19.77
.772	143.2	20.23
.772	142.8	20.29
1896.759	143.4	20.10

λ_1 490.

Cord. G.C. 31884

$\alpha = 23^h\,28^m\,32^s.6$; $\delta = -35^\circ\,3'\,50''.8$

A B

8.1, yellow ; 12.2, bluish

1896.758	224.6	8.16
.760	[230. ±]	[10. ±]
.772	224.8	8.84
1896.763	224.7	8.50

C, 13.5, bluish.

A C

1896.772	331.9	23.04

λ_1 491.

Cord. G.C. 31885

$\alpha = 23^h\,28^m\,35^s.7$; $\delta = -34^\circ\,12'\,51''.8$

8.1, yellow ; 12.7, bluish

1896.717	77.1	18.79
.791	72.4	18.31
.791	73.1	17.84
1896.767	74.2	18.31

λ_1 492 = G 19 *Sculptoris.*

Cord. G.C. 31917

$\alpha = 23^h\,30^m\,23^s.5$; $\delta = -28^\circ\,2'\,17''.5$

6.2, yellow ; 8.1, bl. yellow

1897.796	264.6	0.36
.796	265.6	0.40
1897.796	265.1	0.38

Very interesting close double.

λ_1 493.

Anon., near Cord. G.C. 31963

$\alpha = 23^h\,32^m\,54^s.6$; $\delta = -25^\circ\,46'\,25''.3$

B C

11, bl. yellow ; 11, bl. yellow

t	θ_o	ρ_o
	°	″
1897.753	263.3	1.79
.753	262.3	1.72
1897.753	262.8	1.75

A = Cord. G.C. 31963, 7, yellow.

$A,\ \frac{BC}{2}$

1897.753	206.4	36.16

Curious faint system near a bright star.

λ_1 494.

Cord. Z.C. 23h957

$\alpha = 23^h\,36^m\,14^s.7$; $\delta = -34^\circ\,44'\,47''.6$

8, yellow ; 10.5, yellow

1896.698	213.3	0.98 est. 0″.5
.731	213.3	0.65
.731	208.3	0.84
1896.720	211.6	0.82

Fine close system; distance probably over measured, most likely about 0″.5.

λ_1 495.

Cord. Z.C. 23h1205

$\alpha = 23^h\,45^m\,44^s.9$; $\delta = -34^\circ\,7'\,3''.1$

8, yellow ; 11.3, bluish

1896.703	18.1	2.41
.731	16.8	2.22
.731	14.5	2.09
1896.722	16.5	2.34

λ_1 496.

Cord. G.C. 32206

$\alpha = 23^h\,46^m\,16^s.3$; $\delta = -32^\circ\,59'\,11''.9$

7.8, yellow ; 13.7, bluish

1896.753	193.5	15.89
.772	189.3	16.66
.772	190.0	16.75
1896.766	190.9	16.43

λ_1 497.

Cord. G.C. 32216

$\alpha = 23^h\,46^m\,43^s.2$; $\delta = -28^\circ\,52'\,58''.5$

8, yellow ; 13.6, bl. purple

1896.799	71.4	4.95
.829	71.0	5.09
.843	68.4	5.33
.843	68.3	5.37
1896.828	69.8	5.18

Interesting system.

λ_1 498 *C*.

Cord. G.C. 32219
$\alpha = 23^h\ 47^m\ 15^s.8$; $\delta = -28°\ 55'\ 46''.7$
9.3, yellow ; 13.5, purple

t	θ_o	ρ_o	
	°	″	
1896.829	175.2	[5.24]	C
.843	177.9	4.42	C
.843	176.8	4.30	C
1896.839	176.6	4.36	C
1896.843	177.6	3.91	See

Delicate and interesting star.

Lowell Observatory, 1898 *Jan.* 1.

λ_1 499.

Cord. G.C. 32352
$\alpha = 23^h\ 55^m\ 4^s.0$; $\delta = -40°\ 44'\ 54''.0$
8.5, yellow ; 8.8, yellow

t	θ_o	ρ_o
	°	″
1896.649	263.7	0.9 ±
.728	272.6	0.58
.728	274.6	0.86
1896.702	270.3	0.78

An elegant system in constellation *Phoenix*.

λ_1 500.

Cord. G.C. 32423
$\alpha = 23^h\ 59^m\ 45^s.3$; $\delta = -33°\ 2'\ 49''.0$
7.9, yellow ; 11, bluish

t	θ_o	ρ_o
	°	″
1896.703	201.6	0.91
.728	203.1	0.82
.728	204.4	1.04
1896.720	203.0	0.92

A fine close system.

NOTES ON VARIABLE STARS, — No. 23,

By HENRY M. PARKHURST.

SS Cygni. The entire maximum phase is comprised within 17 days, or less for small apertures. Although the form of the light-curve is unsymmetrical, a close approximation to maximum may be obtained from two or three observations, by comparison with it.

	Light-curve	
m	d	d
9.0	−1.15	+1.40
9.5	1.85	2.75
10.0	−2.24	+4.28
10.5	−2.54	+5.79
11.0	−2.85	+7.20

The maxima given in the table are derived from the time of ascent; and show the intervals to have been 50.8 and 63.5 days, the second being one-fourth longer than the first. Adding one-fourth to this last interval, which has been twice repeated, we have 79 days, the sum of the remaining two intervals, 36 and 43 days, cited by J. A. PARKHURST in *Pop. Astr.*, 1897 July.

RESULTS OF OBSERVATIONS.

No.	Star	Phase	Observed Date		E	Corr.	W	Mag.	Factors			Remarks
			Julian	Calendar								
				1897-98							d	
7468	*T Aquarii*	Max.	4092	June 16	64	−17	3	–	–	–	–	
"	"	Max.	4108	July 2	64	− 1	3P	–	–	–	–	
"	"	Min.	4227	Oct. 29	65	+ 2	5	14.36	1.01	0.41	88	Satisfies the observations
7502	*X Delphini*	Min.	4162 :	Aug. —	–	–	–	13.0]	–	–	–	
"	"	Max.	4308 :	Jan. —	–	–	1	9.2	–	–	–	Possibly later: < 280d ?
7560	*R Vulpeculae*	Max.	4143	Aug. 6	85	− 5	5P	7.7	–	–	–	
"	"	Max.	4279	Dec. 20	86	− 8	6	8.3	–	–	–	
7571	*V Capricorni*	Max.	4174	Sept. 6	70	−31	2	–	–	–	–	
7590	*Z Capricorni*	Min.	4114 :	July 8	2	–	E :	13]	–	–	–	
"	"	Max.	4242	Nov. 13	2	−68	9	9.52	0.48	0.87	19	—8, from period *A.J.* 372
7659	*T Capricorni*	Max.	4228	Oct. 30	57	+ 6	9	9.11	0.65	0.46	18	
7733	*Y Capricorni*	Max.	4116	July 10	21	–	E	–	–	–	–	412d ; see note to Catalogue
7792	*SS Cygni*	Max.	4147.3	Aug. 10	–	–	–	–	–	–	–	From obsns. of J. A. P.
"	"	Max.	4198.1	Sept. 30	–	–	–	–	–	–	–	See note above
"	"	Max.	4261.6	Dec. 2	–	–	–	–	–	–	–	Cloudy at maximum
7896	*V Pegasi*	Max.	4270	Dec. 11	–	–	9	9.90	0.77	0.83	23	See J. A. P. in *A.J.* 405
7944	*T Pegasi*	Max.	4090	June 14	32	+ 3	7	9.0	0.44	0.28	12	Confirms period
7999	*X Aquarii*	Max.	4284	Dec. 24	3	−11	2	8.97	–	–	–	Appeared suddenly
8068	*S Lacertae*	Max.	4278	Dec. 19	10	+18	5P	8.1	–	–	–	Long interruption at max.
8153	*R Lacertae*	Max.	4252	Nov. 23	18	− 1	7P	10.7	–	–	–	
8369	*W Pegasi*	Max.	4178	Sept. 10	–	–	6	7.6	0.20	0.20	6	
"	"	Max.	4162	Aug. 25	–	–	8P	7.9	1.2	1.7	56	
8373	*S Pegasi*	Max.	4307	Jan. 17	38	+32	3P	8.1	–	–	–	From ascending curve
8512	*R Aquarii*	Max.	4178	Sept. 10	81	− 9	2	6.4	–	–	–	Possibly earlier
8622	*W Ceti*	Max. A	4273	Dec. 14	2	−27	9	9.46	–	–	–	WEST'S "standstill"; *A.J.* 414
103	*T Andromedae*	Max.	4292.1	Jan. 2	8	+19	9	8.62	0.88	1.03	24	(+65). Elements *A.J.* 420
"	"	Max.	4294	Jan. 4	8	+21	6P	8.5	–	–	–	
419	*U Andromedae*	Max.	4238	Nov. 9	3	−47	6	9.7	–	–	–	Period 349 days ?
466	*U Piscium*	Max.	4302.3	Jan. 12	38	+17	9	10.92	0.77	0.88	26	

Individual Observations.

Including Observations by Arthur C. Perry.

7468 *T Aquarii.*

(Continued from 393.)

Julian	Calendar		Mag.
	1897		
4078.7	June	2	9.0
4090.7		14	8.5
4091.7		15	8.31_2
4094.7		18	8.7
4097.7		21	8.2P
4098.7		22	8.8
4102.7		26	8.0P
4103.7		27	8.7
4111.6	July	5	8.8
4114.6		8	8.6
4115.6		9	8.3P
4121.6		15	8.6P
4128.6		22	8.9P
4140.6	Aug.	3	9.2P
4165.5		28	10.66_2
4182.6	Sept.	14	12.0]
4185.6		17	12.64_2
4194.6		26	13.0]
4214.5	Oct.	16	13.0]
4224.5		26	13.0]
4241.5	Nov.	12	13.1
4247.5		18	11.00_2
4253.5		24	11.19_2

7502 *X Delphini.*

(Continued from 400.)

	1897		
4077.7	June	1	12.5
4087.7		11	12.0]
4094.7		18	12.8]
4103.7		26	to
4215.5	Oct.	17	13.0]
	5 dates		
4247.5	Nov.	18	12.33_2
4252.5		23	11.20_2
4256.5		27	10.47_2
4270.5	Dec.	11	10.38_2
4271.5		12	10.0P
4278.5		19	9.37_2
4282.5		23	9.30_2
4285.5		26	9.47_2
	1898		
4292.5	Jan.	2	9.34_2
4295.5		5	9.23_2
4297.5		7	9.43_2
4303.5		13	9.30
4308.5		18	9.17_2

7560 *R Vulpeculae.*

(Continued from 400.)

	1897		
4128.7	July	22	8.3P
4140.7	Aug.	3	7.7P
4157.6		20	8.6P
4163.6		26	8.9P
4168.6		31	9.3P
4265.5	Dec.	6	8.90_2
4270.5		11	8.46_2
4278.5		19	8.33_2
4285.5		26	8.46_2
	1898		
4291.5	Jan.	1	8.74_2

7571 *V Capricorni.*

(Continued from 339.)

Julian	Calendar		Mag.
	1897		
4173.6	Sept.	5	9.6
4174.6		6	9.06_2
4182.5		14	9.28_2
4186.6		18	9.72_2
4192.6		24	9.99_2
4198.6		30	10.49_2
4212.5	Oct.	14	10.7

7590 *Z Capricorni.*

(Cont from 400. Comp. Stars 372)

	1897		
4128.6	July	22	to
4165.6	Aug.	28	13.0]
	4 dates.		
4183.5	Sept.	15	12 8
4186.5		18	12.81_2
4215.5	Oct.	17	11.85_2
4224.6		26	11.03_2
4226.5		28	9.84_2
4229.5		31	9.55_2
4232.5	Nov.	3	9.65_2
4233.5		4	10.00_2
4235.5		6	9.78_2
4238.5		9	9.51_2
4239.5		10	9.54_2
4247.5		18	9.77_2
4253.5		24	9.98_2
4256.5		27	10.15_2
4270.5	Dec.	11	10.8

7659 *T Capricorni.*

(Continued from 339.)

	1897		
4172.7	Sept.	4	11.5]P
4184.5		16	10.9
4193.5		25	10.8
4198.5		30	10.57_2
4206.6	Oct.	8	9.73_2
4211.5		13	10.06_2
4216.5		18	9.18_2
4224.5		26	9.4P
4224.6		26	9.41_2
4228.5		30	9.26_2
4232.5	Nov.	3	8.92_2
4232.5		3	9.4P
4235.5		6	9.45_2
4238.5		9	9.78_2
4239.5		10	9.72_2
4253.5		24	10.1P
4270.5	Dec.	11	10.7P

7733 *Y Capricorni.*

(Continued from 372.)

	1897		
4111.7	July	5	12.5]
4128.6		22	12.5]

7792 *SS Cygni.*

	1897		
4138.6	Aug.	1	11.7
4149.6		12	8.45_2
4150.6		13	8.73_2

7792 *SS Cygni.*—Cont.

Julian	Calendar		Mag.
	1897		
4151.6	Aug.	14	9.28_2
4157.6		20	11.44_2
4159.6		22	11.75_2
4163.6		26	12.0 :
4183.6	Sept.	15	11.7
4184.5		16	11.63_2
4185.6		17	to
4193.6		25	11.7
	8 dates		
4194.6		26	11.5
4195.61		27	10.55_4
4196.50		28	9.16_2
4197.50		29	8.71_2
4198.50		30	8.92_2
4199.50	Oct.	1	8.81_2
4245.5	Nov.	16	11.5 :
4246.6		17	11.66_2
4252.5		23	11.68_2
4246.6		17	to
4258.5		29	11.7
	10 dates.		
4256.5		27	11.7P
4259.44		30	10.0
4259.60		30	9.67_4
4261.5	Dec.	2	8.8 :
4264.4		5	9.68_2
4265.4		6	9.57_2
4268.4		9	10.49_2
4269.4		10	10.61_2

7896 *V Pegasi.*

	1896		
3755.6	July	14	to
	1897		
3931.5	Jan.	6	11.0]
	9 dates.		
4136.6	July	30	11.8]
4165.6	Aug.	28	11.5]
4221.5	Oct.	23	10.8]
4225.5		27	11.65_2
4228.5		30	11.23_2
4246.6	Nov.	17	10.64_2
4253.5		24	10.20_2
4257.5		28	10.28_2
4271.5	Dec.	12	9.98_2
4272.5		13	9.85_2
4278.5		19	9.87_2
4282.5		23	10.35_2
4287.5		28	10.25_2
	1898		
4303.5	Jan.	13	10.67_2

7944 *T Pegasi.*

(Continued from 400.)

	1897		
4078.7	June	2	9.14_2
4087.7		11	9.20_4
4090.7		14	8.84_2
4091.7		15	8.93_4
4094.7		18	9.22_2
4096.7		20	9.32_2

7999 *X Aquarii.*

Julian	Calendar		Mag.
	1895		
3475.5	Oct.	8	12]
3510.5	Nov.	12	13 :
3540.5	Dec.	12	13 :
	1896		
3809.6	Sept.	6	to
3918.5	Dec.	24	12]
	6 dates.		
	1897		
4224.5	Oct.	26	to
4270.5	Dec.	11	12]
	4 dates.		
4283.5		24	9.0
4284.5		25	8.97_3
4285.5		26	9.20_2
4287.5		28	9.19_2

8068 *S Lacertae.*

(Continued from 372.)

	1897		
4228.6	Oct.	30	11.1P
4232.6	Nov.	3	10.7P
4252.6		23	10.6P
4258.6		29	9.8P
4270.5	Dec.	11	8.1P
4278.5		19	8.1P
	1898		
4306.5	Jan.	16	10.2P

8153 *R Lacertae.*

(Continued from 346.)

	1897		
4228.6	Oct.	30	11.3P
4232.6	Nov.	3	11.0P
4252.6		23	10.7P
4258.6		29	10.7P
4270.5	Dec.	11	10.9P
4278.5		19	11.1P
	1898		
4306.5	Jan.	16	11.2]P

8369 *W Pegasi.*

(Continued from 400.)

	1897		
4128.7	July	22	9.0P
4140.7	Aug.	3	8.2P
4157.6		20	7.8P
4161.6		24	8.0P
4165.6		28	8.0P
4172.7	Sept.	4	7.8P
4174.5		6	8.09_2
4176.5		8	7.67_2
4178.6		10	7.60_2
4184.5		16	8.14_2
4201.5	Oct.	3	8.5P
4215.5		17	8.7P

8373 *S Pegasi.*

(Continued from 372.)

	1897		
4252.6	Nov.	23	9.0P
4253.6		24	9.1P
4256.5		27	9.2P
4258.5		29	9.1P
4270.5	Dec.	11	8.5P
4278.5		19	8.5P
	1898		
4306.5	Jan.	16	8.1P

8512 *R Aquarii.*

(Continued from 346.)

Julian	Calendar		Mag.
	1897		
4178.6	Sept.	10	6.45_2
4182.6		14	7.50_2
4185.6		17	7.62_2
4188.6		20	8.03_2

8622 *W Ceti.*

(Continued from 400.)

	1897		
4211.5	Oct.	13	10]
4224.5		26	11.3
4247.5	Nov.	18	10.1
4253.5		24	10.05_2
4257.5		28	10.00_2
4258.5		29	9.82_2
4271.5	Dec.	12	9.34_2
4271.5		12	9.5P
4278.5		19	9.46_2
4282.5		23	9.69_2
	1898		
4291.5	Jan.	1	9.60_2
4297.5		7	9.37_2
4203.5		13	9.41_2
4308.5		18	9.36_2

103 *T Andromedae.*

(Continued from 400.)

	1897		
4188.6	Sept.	20	13.0 :
4213.6	Oct.	15	12.7
4221.5		23	11.6
4228.6		30	11.98_2
4232.6	Nov.	3	11.6P
4246.6		17	10.6P
4252.6		23	10.2P
4253.6		24	10.71_2
4256.5		27	10.4P
4268.5	Dec.	9	9.13_2
4270.5		11	9.17_2
4270.5		11	9.5P
4277.5		18	8.78_2
4278.5		19	8.6P
4282.5		23	8.80_2
4285.5		26	8.80_2
	1898		
4293.5	Jan.	3	8.49_2
4297.5		7	8.71_2
4303.5		13	8.87_2
4306.5		16	8.7P
4316.5		26	9.00_2
4324.5	Feb.	3	9.64_2
4333.5		12	10.5P

419 *U Andromedae.*

	1897		
4221.5	Oct.	23	10.37_2:
4224.5		26	10.0P
4225.5		27	10.04_2
4232.6	Nov.	3	10.0P
4246.7		17	10.4P
4247.5		18	9.75_2
4253.6		24	10.32_2

419 *U Androm.* — Cont.			
Julian	Calendar		Mag.
	1897		
4253.6	Nov.	24	10.2r
4256.5		27	10.24_2
4271.5	Dec.	12	10.71_2
4271.5		12	10.4r
4277.5		18	10.23_2

419 *U Androm.* — Cont.			
Julian	Calendar		Mag.
	1897		
4278.5	Dec.	19	10.7r
4283.5		23	10.8
	1898		
4306.5	Jan.	16	11.0r
4314.5		21	11.5]
4333.5	Feb.	12	11.5]r

466 *U Piscium.* (Continued from 400.)			
Julian	Calendar		Mag.
	1897		
4214.5	Oct.	16	12.5]
4271.5	Dec.	12	11.83_2
4272.5		13	12.08_2
4278.6		19	11.09_2

466 *U Piscium.* — Cont.			
Julian	Calendar		Mag.
	1897		
4284.5	Dec.	25	11.53_2
4285.5		26	11.68
	1898		
4306.5	Jan.	16	10.91_2
4307.5		17	10.94_2

466 *U Piscium* — Cont.			
Julian	Calendar		Mag.
	1898		
4308.5	Jan.	18	10.97_2
4316.5		26	11.20_2
4324.5	Feb.	3	11.14_2

TWO NEW VARIABLES OF SHORT PERIOD.

By G. Müller and P. Kempf.

In the course of our observations for the Second Part of the Potsdam Photometric *Durchmusterung* we have discovered two new variable stars of short period, the elements of which we have been able to determine pretty accurately by means of a large number of measures. The stars are

$$\left.\begin{array}{llll}\text{B.D. } +20^\circ 4200 & \alpha = 19^h 32^m 15^s & ; & \delta = +20^\circ 6'.6 \\ \text{B.D. } +28^\circ 3460 & \alpha = 19\ 40\ 49 & ; & \delta = +29\ 1.2\end{array}\right\} 1900.0$$

The elements deduced are

B.D. +20°4200 Max. = Gr. M.T. 1897 Oct. 2.47 $+8^d.00$ E

B.D. +28°3460 Max. = Gr. M.T. 1897 Oct. 4.66 $+3^d.844$E

The light-curve for +20°4200 is quite symmetrical; but in the case of +28°3460 the increase is much more rapid than the decrease, the time occupied from minimum to maximum being only about 0.9 days, while that from maximum to minimum is 2.9 days. An examination of all the observations (which will be published in full in the *Astr. Nachr.*) gave the following light-curves:

+20°4200				+28°3460			
t	Magn.	*t*	Magn.	*t*	Magn.	*t*	Magn.
d		d		d		d	
0.0	6.94	4.4	7.59	0.0	6.57	2.0	7.23
0.4	6.97	4.8	7.54	0.2	6.65	2.2	7.27
0.8	7.03	5.2	7.46	0.4	6.73	2.4	7.31
1.2	7.11	5.6	7.37	0.6	6.82	2.6	7.34
1.6	7.19	6.0	7.28	0.8	6.89	2.8	7.37
2.0	7.28	6.4	7.19	1.0	6.97	3.0	7.37
2.4	7.37	6.8	7.11	1.2	7.03	3.2	7.23
2.8	7.46	7.2	7.03	1.4	7.08	3.4	7.05
3.2	7.54	7.6	6.97	1.6	7.14	3.6	6.85
3.6	7.59	8.0	6.94	1.8	7.18	3.8	6.63
4.0	7.61						

t is the interval, in days from the epoch of maximum.

Potsdam, Astrophysikalisches Observatorium, 1898 *March* 8.

COMET *b* 1898.

A comet was discovered on March 20, by Perrine, at the Lick Observatory. It is described as of the seventh magnitude, 2′ in diameter, with strong central condensation and tail. Three positions and an orbit computed from them by Messrs. Hussey and Perrine have been telegraphically communicated by Prof. Schaeberle, as follows:

1898 Gr. M.T.	α	δ	Obs.
	h m s	° ′ ″	
March 20.0374	21 18 36.9	+16 43 23	Perrine
22.0532	21 25 59.8	+18 49 17	Hussey
22.9855	21 29 28.9	+19 47 24	Perrine

Elements.

T = 1898 March 18.67 Gr. M.T.

$$\left.\begin{array}{rl}\omega = & 49^\circ\ 2' \\ \Omega = & 264\ \ 7 \\ i = & 72\ 48\end{array}\right\} 1898.0$$

q = 1.1013

Ephemeris for Greenwich Midnight.

	α	δ	Br.
	h m s	° ′	
1898 March 26.5	21 44 24	+23 23	0.99
30.5	22 0 28	+27 26	
1898 April 3.5	22 17 32	+31 21	
7.5	22 35 32	+35 4	0.89

Dr. Leuschner, of the University of California, also telegraphs the following orbit, computed from the same observations by Messrs. Crawford and Palmer.

Elements.

T = 1898 April 8.61 Gr. M.T.

$$\left.\begin{array}{rl}\omega = & 72^\circ\ 46' \\ \Omega = & 271\ 21 \\ i = & 78\ 45\end{array}\right\} 1898.0$$

q = 1.0687

Ephemeris for Greenwich Midnight.

	α	δ	Br.
	h m s	° ′	
1898 March 25.5	21 39 24	+22 29	1.10
29.5	21 56 16	+26 48	
April 2.5	22 14 48	+31 4	
6.5	22 34 56	+35 14	1.22

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